December 25, 1961

CHEMICAL ENGINEERING

cGraw-Hill Publication / Published every-other-Monday / Seventy-five cents

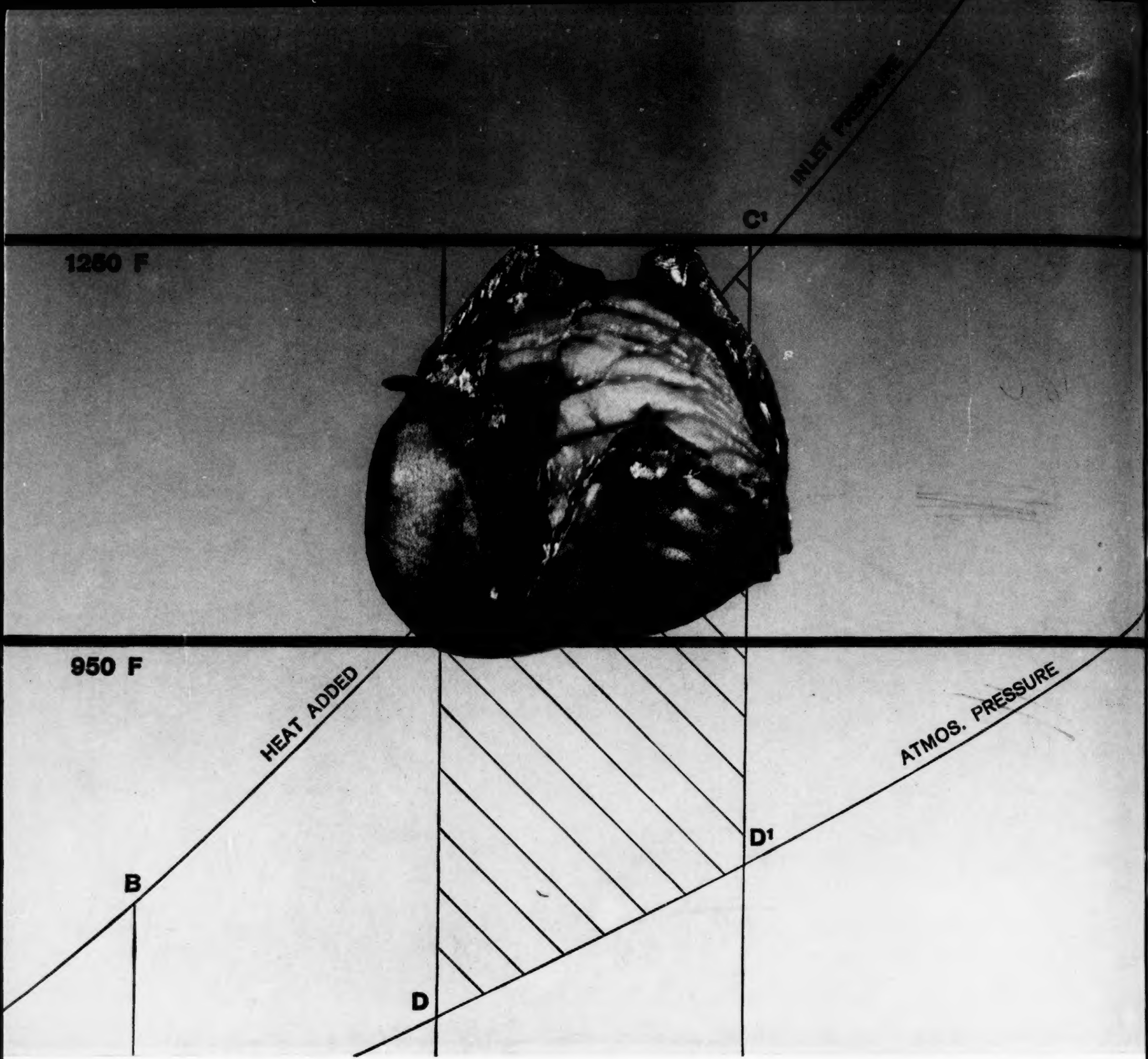
660

~~R-2~~

~~A-4~~

CONTENTS PAGE THREE

Chemistry's Gift: Synthetic Gems


INLET PRESSURE
C¹
1250 F
950 F
HEAT ADDED
ATMOS. PRESSURE
D¹
B
D

Form 85 Unilets

The advantages of aluminum combined with Appleton manufacturing standards for dependable performance now make available a wide selection of rugged, serviceable pressure cast aluminum fittings to give you easier electrical installations . . . faster, more economical!

Your distributor has them now. The complete line includes seven of the most popular types in ½", ¾" and 1" sizes to meet most job requirements. When you use them, you will agree . . . they are outstanding in every respect—from design to manufacturing excellence.

BEFORE YOU BUY OR SPECIFY . . . CHECK THESE APPLETON QUALITY FEATURES

Easy to use—roomy • Lightweight—durable • Taper Tapped threading • Precision hub alignment • Chamfered hub edges • Pressure cast smoothness • Reinforced points of stress • Easy-to-read cast identification • Attractive, practical design • Low cost—high quality • Wide assortment of covers available.

Contact your distributor or write for bulletin No. AL 60. It includes details for the entire *aluminum* product line by Appleton: Form 85 and larger sizes in Form 35 Unilets, FS and JB fittings and V-51 lighting fixtures.

Sold through franchised distributors only

APPLETON electric company

Also manufacturers of:

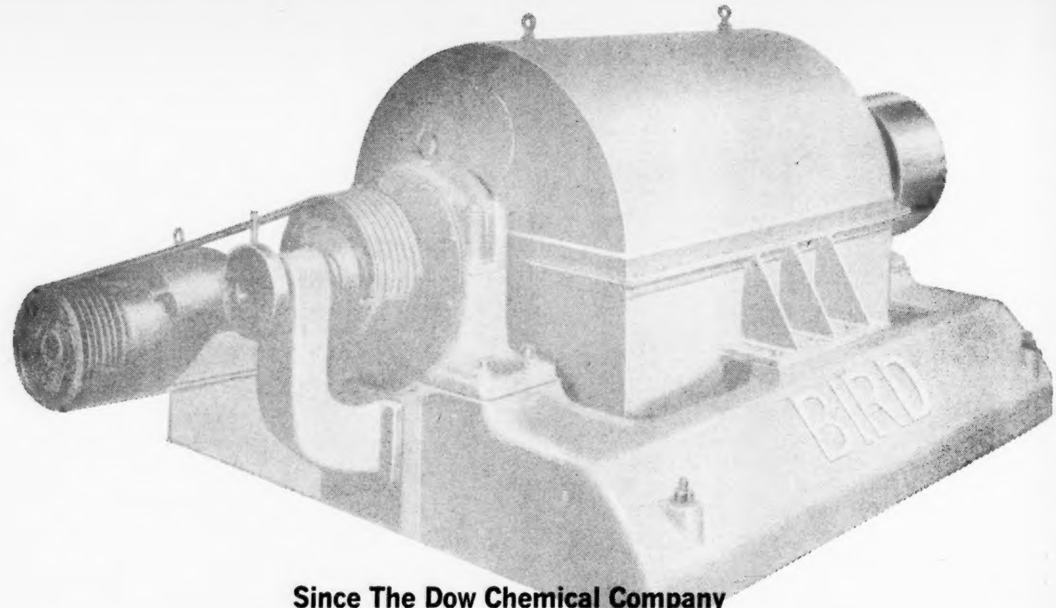
Explosion-Proof Lighting Fixtures

Industrial Lighting

Automatic Reelites

Outlet Boxes, Covers, Switch Boxes

1701 Wellington Avenue, Chicago 13, Illinois



DOW

Since The Dow Chemical Company ordered their first BIRD Continuous Centrifugal eighteen years ago, they've sent us twenty-six repeat orders. You'll find BIRDS on the job in Dow plants from Midland and Ludington, Michigan to Pittsburg, Cal., to Freeport, Texas.

This clean, dependable method of separating solids from liquids has demonstrated its efficiency and economy for many users.

Examine your own solid-liquid separating methods and equipment. The Bird Research and Development Center is prepared to supply the facts and figures.

BIRD MACHINE COMPANY

SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT

Operators of the **Bird Research and Development Center** for pilot-scale testing to determine the correct equipment for the job. Yours to use.

Application Engineering Offices:

EVANSTON, ILL. • ATLANTA, GA. • HUNTINGTON, W. VA. • WALNUT CREEK, CALIF.

CHEMICAL ENGINEERING

December 25, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

* FREE—For an extra copy of this article, Check Reader Service Card, p. 145.

OTHER REGULAR FEATURES

PRINT ORDER FOR THIS ISSUE 53,765

VOLUME 68, NUMBER 26

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y. **Officers of the Publications Division:** Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator; Daniel F. Crowley, Vice President and Controller. **Officers of the Corporation:** Donald C. McGraw, President; Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Executive Vice President and Treasurer; John J. Cooke, Vice President and Secretary.

Subscriptions are solicited from engineers and other technical men in the Chemical Process Industries. Publisher reserves the right to refuse non-qualified subscriptions. **Position, company connection, and nature of company's business, products, and approximate number of employees, must be indicated on subscription application.** Subscription rates per year for individuals in the field of the publication: U. S. and Possessions \$3 (single copies 75¢). Canada \$4, other Western Hemisphere \$15, all others \$25. **Unconditional guarantee:** The publisher, upon written request from any subscriber, agrees to refund the part of the subscription price applying to copies not yet mailed.

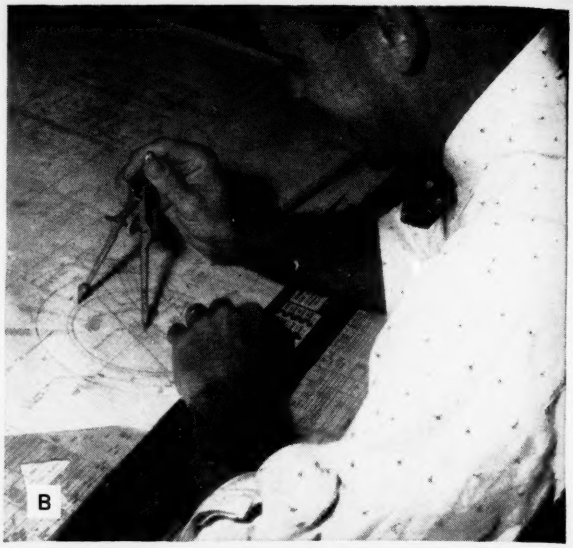
Printed in Albany, N. Y.; second class postage paid at Albany, N. Y. and at additional mailing offices.

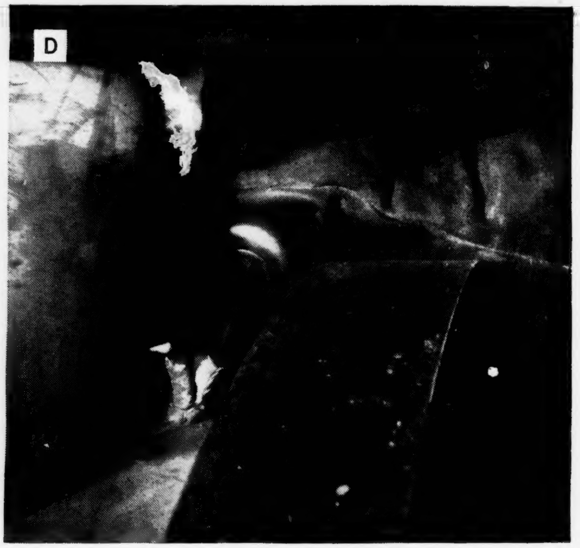
Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

Postmaster: Please send form 3579 to Chemical Engineering, 330 W. 42nd St., New York 36, N. Y.

Audit Bureau of Circulation

Associated Business Publications





Where skillful hands work for you

Craftsmanship follows through on every stage of the design and fabrication of pressure vessels and heat exchangers at Downingtown Iron Works. Come and see for yourself. Inspect our shop procedures on work in normal progress. Or write for helpful Bulletins HE and CI.

A **On the nose**—Accurate fit-up...a second check after tack welding...another before shipment...assure nozzles are on the nose, save installation headaches.

B **Detailing your ideas**—in language the shop man understands—means that equipment fabricated here carries out your plans, meets your process requirements.

C **"X" marks the spot**—and punch mark guides true center of tube hole...holds close ligament tolerances...assures accurate tube sheets and efficient operation.

D **A Downingtown extra**—Back-chipping nozzle weld assures sound weld metal through and through...is one of the DIW extras that go beyond code requirements.

Downingtown Iron Works, Inc.

140 Wallace Ave., Downingtown, Pennsylvania

division of **PRESSED STEEL TANK COMPANY** Milwaukee

Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

CHEMICAL ENGINEERING

highlights of this issue

SYNTHETIC GEMS FIND NEW USES IN OPTICS

Any object, animate or inanimate, that combines beauty with utility is indeed a jewel. Linde's new sapphire-encased ruby, used in optical masers, is a good example of why industrial applications now make up the bulk of Linde's market for synthetic gems. How these gems are produced is told in our "cover story" (p. 26).

EXPLOSION SUPPRESSION: NEW SAFETY TOOL

Where absolute prevention of an explosion is difficult to achieve, explosion suppression may be the answer. Monsanto engineer Clayton Hammond tells (p. 81) how a suppression system performed when a dust explosion actually occurred in a hammer mill that was grinding plastics.

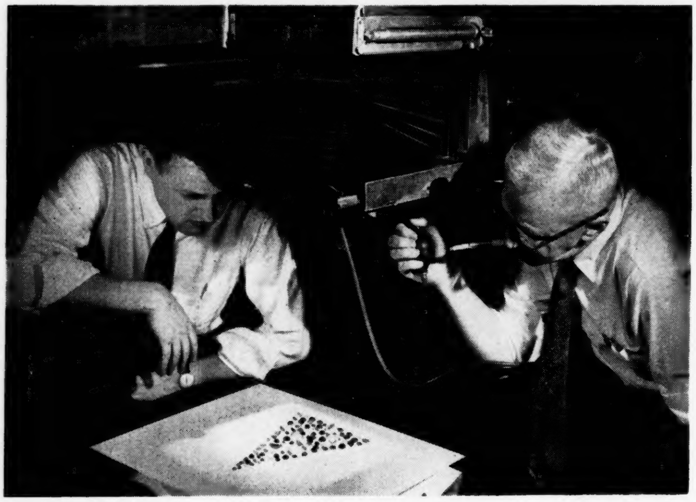
ROCKET FUELS BOOST SPECIAL ALLOYS

Optimum combination of both mechanical properties and corrosion resistance to rocket fuels and oxidizers has drawn attention to a class of alloys little known to chemical engineers. These are the precipitation-hardening stainless steels whose Cr-Ni content is indicated by the designations 17-4, 17-7 and 15-7. See Corrosion Forum (p. 108) for useful data on properties and performance.

USE WET FLUID BEDS TO HUMIDIFY GASES

Prof. Norman Epstein of University of British Columbia is apparently the first to propose using fluid beds specifically for the purpose of humidifying gases. In this article (p. 86), he presents experimental data from a 12-in.-dia. fluid-bed humidifier to support his thesis that such devices have certain advantages over conventional spray chambers.

CE Christmas cover is no shot-in-the-dark



That seemingly random arrangement of synthetic gems in our front cover illustration came about through the studied efforts of Senior Art Editor Frank Kozelek (left) and McGraw-Hill's chief photographer, Hans Basken. One major problem: finding the optimum lighting arrangement for bringing out the "Christmas stars" in the star sapphires and rubies. We hope you like the result.

Con: Engineering Conservatism

Sir:

Mr. Carroll's article, "Increase Your Plant Profitability" (Nov. 27, pp. 113-8) was a courageous attack on engineering conservatism.

I was rooting for John Bough to receive some tangible recognition for a bold attempt at reducing capital costs. I got the impression he was made more responsible for the design work and received nothing for it.

How about Mike Roe, the production manager, sharing his bonus money with John? After all, John's the guy who helped Mike earn it.

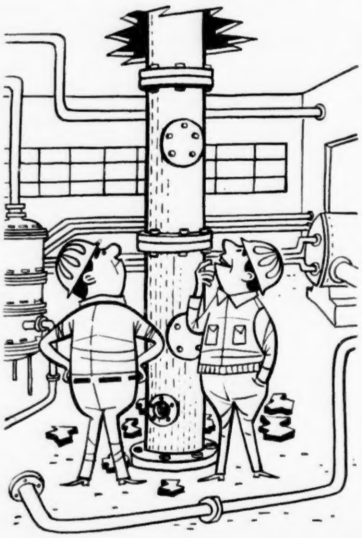
JOHN W. SARAPPO
Titusville, Pa.

Pro: Realistic Design

Sir:

I learned a lot from the delightful article by Wingate H. Richardson in your Oct. 16 issue (pp. 216-20).

I learned that the modern chemical plant designer is no longer required to prove that his design will function as predicted. My comment is: Better get a new top executive.



I learned that the young designer no longer works with unit-operations empirical formulae but creates "models" and "programs" so that technicians may play them on a computer. However, the best and most experienced designer still "assumes" the answer and tries out his assumptions one after another till one works.

I would enjoy meeting Mr. Richardson.

DONALD B. KEYES
New York, N. Y.

Sir:

I have about 50 students in my Engineering Orientation course whom I am trying to enlighten as to the mysteries and ramifications involved in the branches and functions of engineering. Mr. Richardson's article, "Coexistence for Design and Operating Engineers?", is a peach as regards these two functions.

R. L. JOHNSON
Portland State College
Portland, Ore.

Pro: Trichloroethane

Sir:

We note your splendid article in the Oct. 30 issue (pp. 62-6) entitled "Competition Sharpens in Chlorinated Solvents." The article appears to be an excellent summation of the current situation regarding chlorinated solvents, except for your discussion of 1,1,1-trichloroethane.

Tect, Inc., was the first company successfully to stabilize this solvent, initially offering it in early 1954 under the trade name Vythene. More than 95% of all 1,1,1-trichloroethane on the market today is stabilized this way.

In addition, you greatly underestimate the volume of this material being sold. Indeed, there is a temporary shortage, and 1962 sales will be about 80 million lb.

J. W. PATRICK
Tect, Inc.
Northvale, N. J.

Christmas Comes Twenty-Six Times a Year

Every year at this season, the corner mail boxes are filled with letters in childish handwriting addressed to Santa Claus. Most of these letters are mailed before Christmas; according to the Dead Letter Office, rare indeed is the post-holiday letter to Santa expressing gratitude for gifts received.

Even we adults are often guilty of taking too much for granted. Most of you have noted—and some of you have questioned—the seemingly high single-copy price of this magazine, as indicated on the front cover. What many may not realize is that this price approximates our actual out-of-pocket costs for paper, printing and postage.

If it were not for income from advertising sales, therefore, we would have to charge U.S. subscribers $20 per year just to recover these production expenses (and overseas subscribers would have their already higher rates increased). At such prices, our circulation would naturally be smaller, and printing costs per copy produced would be even higher. Effective communication of chemical engineering technology would certainly suffer.

Thus we think it appropriate here to acknowledge the part played by advertisers, who make it possible for us to deliver to you a worthwhile publication at a price you as an individual subscriber can afford to pay.

This editorial is not a plea to support our advertisers, nor are we suggesting that you influence your advertising manager to buy space in CHEMICAL ENGINEERING. Your purchasing decisions are rightfully based on firmer economic grounds than loyalty to a magazine, and an advertiser will buy space only when he wants to gain the attention and readership of those who have prime buying influences for his products.

We simply want you to know that in the economics of independent publishing, there are buyers and sellers, but there is no Santa Claus.

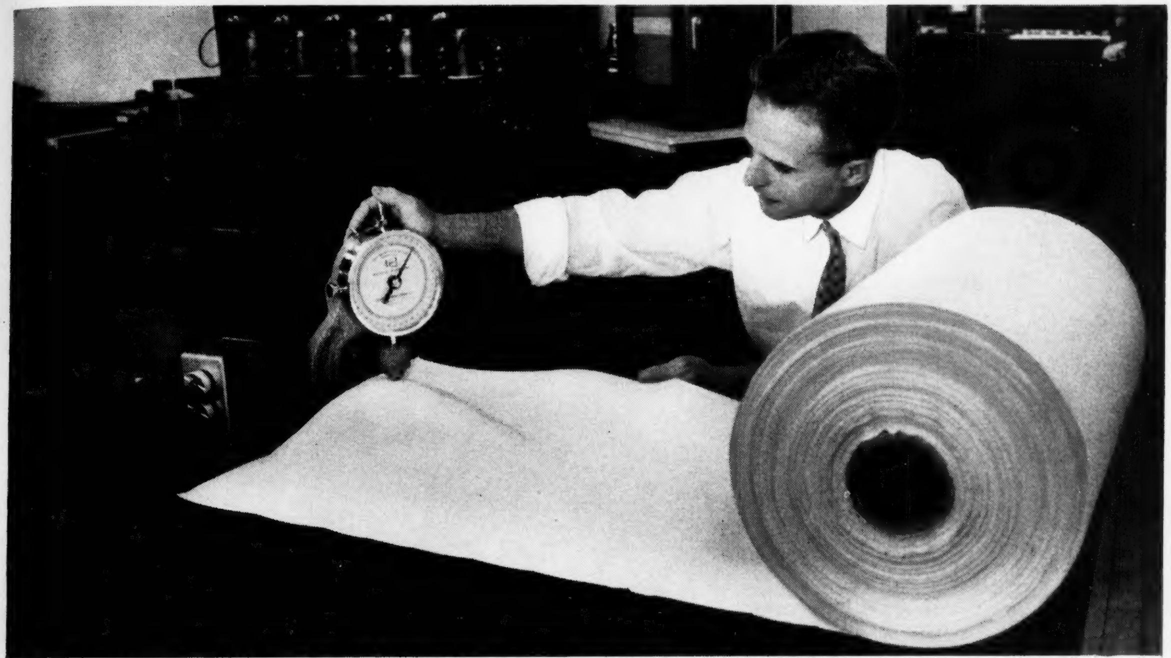
—CECIL H. CHILTON

CYANAMID

Chemical Newsfront

COIN-OP DRY CLEANING. Newest addition to self-service cleaning—Venmist spray, containing Cyanamid's CYANA®-GUARD*. After the regular dry cleaning cycle, clothing is returned to the machine for the finishing touch – the Venmist spray. In addition to restoring moisture to the clothing, the spray's bactericidal action also prevents perspiration odor from developing on the fabric. The treatment lasts until the next time the clothes are cleaned in the Venclene or Venmist machines. This is the first time that CYANA-GUARD, long used in mill-treated fabrics, has been made part of a dry cleaning process. **(Textile Chemicals Department)**

*Trademark



THE VERSATILITY OF PROCESS allows choice of a wide range of basic weights, porosity and thickness to suit your particular needs. Another outstanding feature of this new 100% Acrylic Fiber Sheet is its durability as evidenced by its resistance to rot, common solvents, most chemicals, and ultraviolet light. It is compatible with most coating and impregnating resins and also can be used as a protective or decorative foil in many plastic systems. Its hydrophobic nature, and resultant good dimensional stability, makes this material adaptable to a wide range of new ideas. **(Paper Chemicals Department)**

BEAUTIFUL PROJECTION FROM CYANAMID. The rugged housing for this Tower "Seventy-Five" 500-watt slide projector is made of molded BEETLE® urea plastic. Because of Cyanamid's BEETLE, the projector housing has a corrosion-proof surface, good heat-resistance, and does not build up dust-attracting static charges. **(Plastics and Resins Division)**

$$\begin{matrix} H \\ H \end{matrix} \rangle N-C \equiv N$$

STABILIZING THE CYANAMIDE RADICAL. For the first time, the cyanamide radical is available as a stable, colorless, concentrated 50% aqueous solution of **hydrogen** cyanamide. This new form of an old and useful compound contains a minimum of metallic and nitrogenous contaminants. **(Process Chemicals Department)**

For further information on products in this advertisement wire, or mail this coupon to: CE-121

AMERICAN CYANAMID COMPANY
30 Rockefeller Plaza, New York 20, N.Y.
Dept. 6365

Please send me additional information on

- ☐ VENMIST CYANA-GUARD
- ☐ BEETLE UREA PLASTIC
- ☐ ACRYLIC FIBER SHEET
- ☐ HYDROGEN CYANAMIDE

Name________________

Company________________

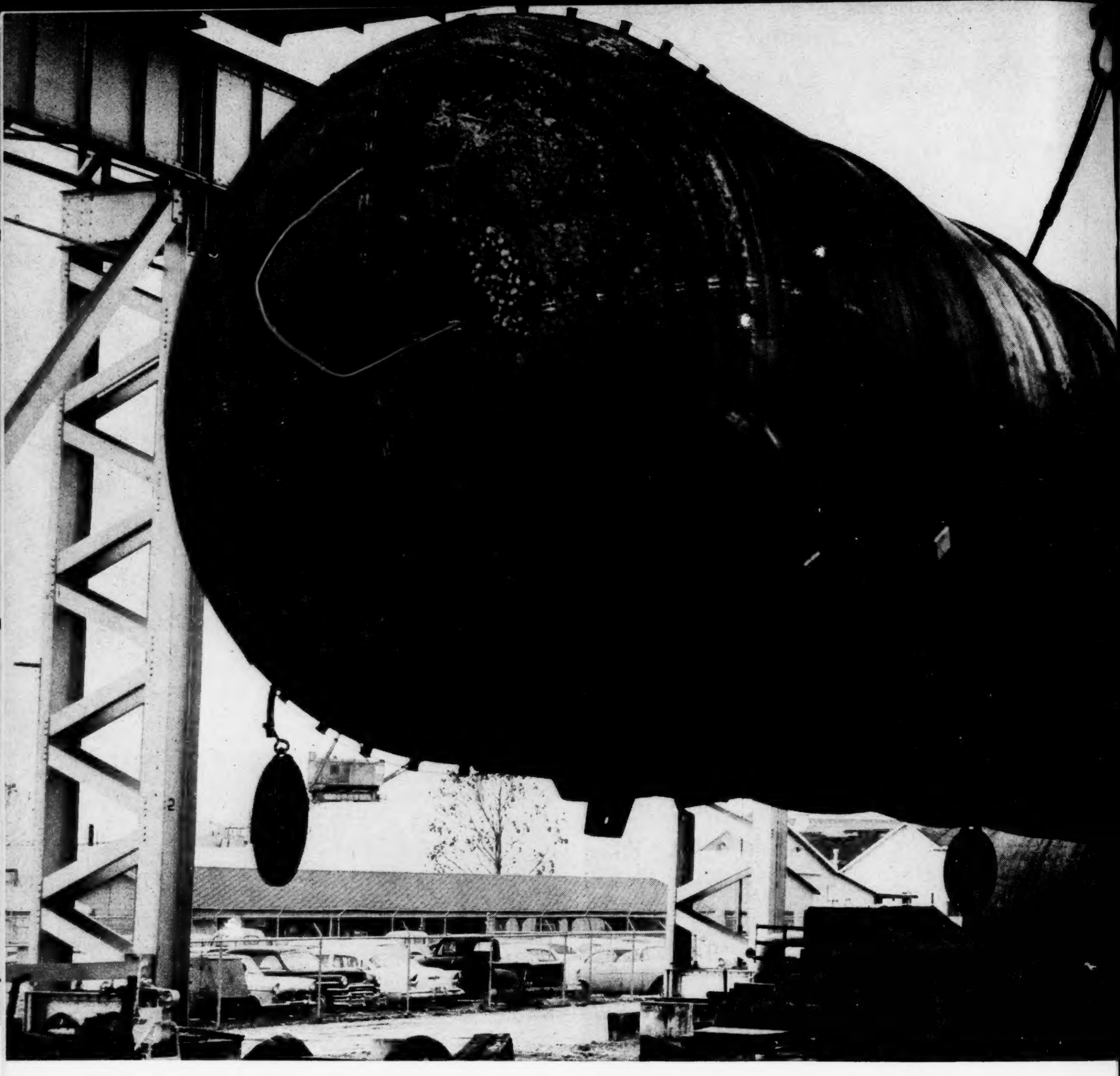
Position or title________________

Address________________

City________ Zone____ State________

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.

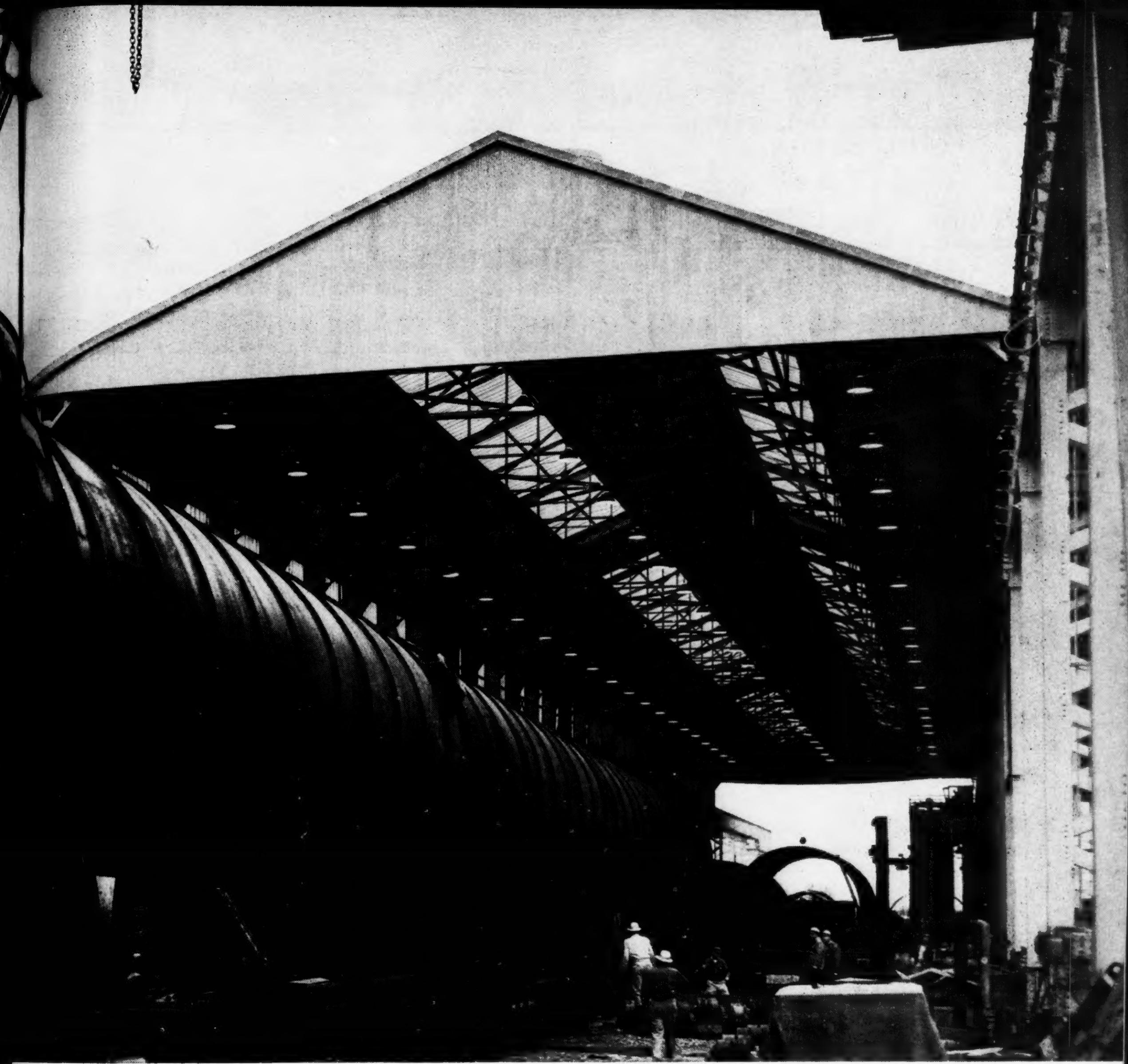


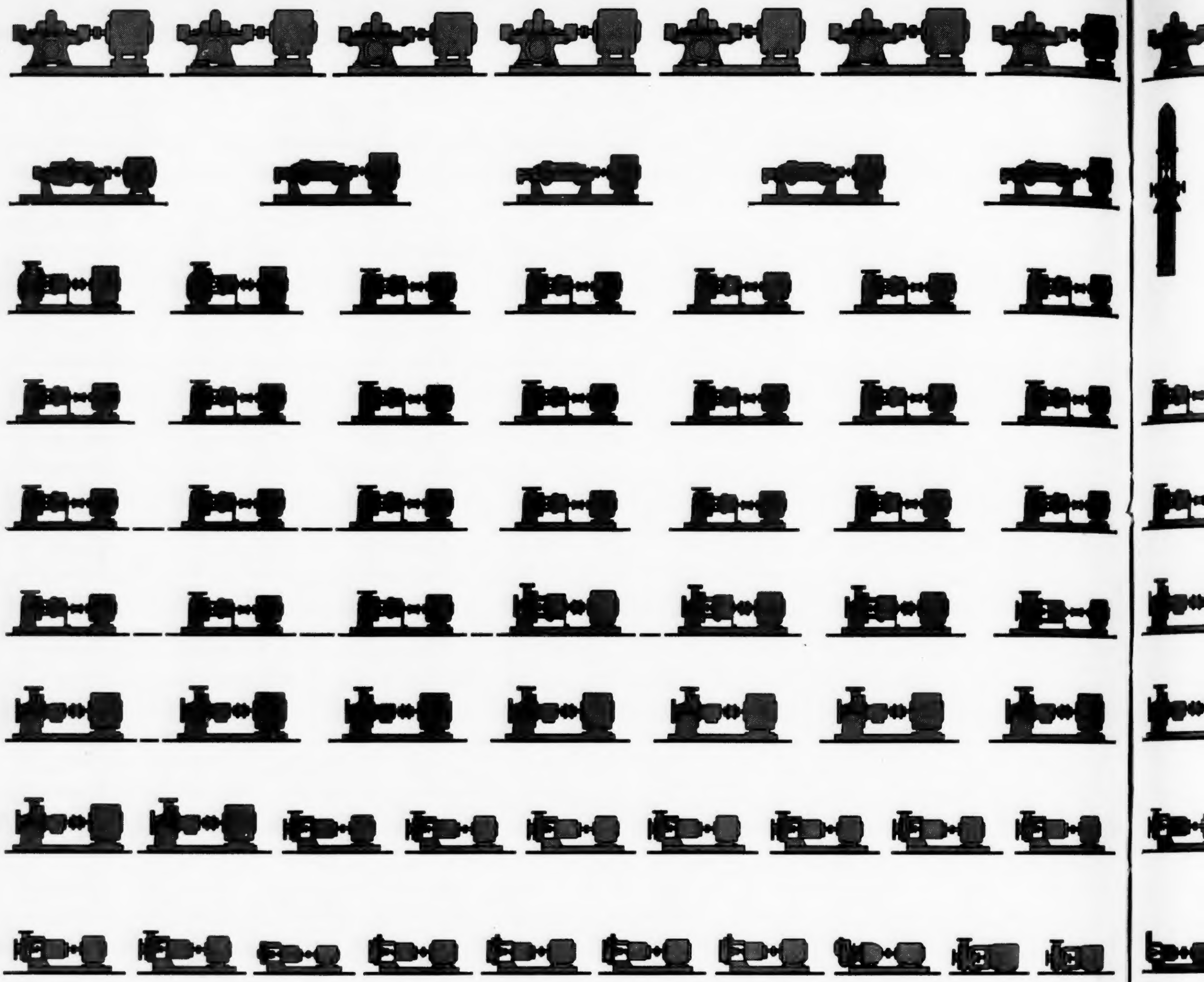
This big fabrication is no tall story

It took <u>six flat cars</u> to ship this giant out of American Bridge's Orange, Texas, plate shop. Over 220′ long and more than 12′ in diameter, this tower is made from 33 steel rings, formed from $1\frac{3}{16}$-inch plates. High capacity boom-mounted electric welders joined the 33 rings, and special x-ray equipment checked the weld seams. ☐ What did we do for an encore? We fabricated three <u>more</u> towers, all about the same size—and weighing over 200 tons each. ☐ Badger Manufacturing Company, Engineers and Constructors, designed and erected the towers for a styrene manufacturing plant* now under construction for Sinclair-Koppers Chemical Company. ☐ King-size, custom fabrication is routine at American Bridge's Orange plate shop. Staffed by experienced experts, completely equipped with modern fabricating facilities,

This mark tells you a product is made of modern, dependable Steel.

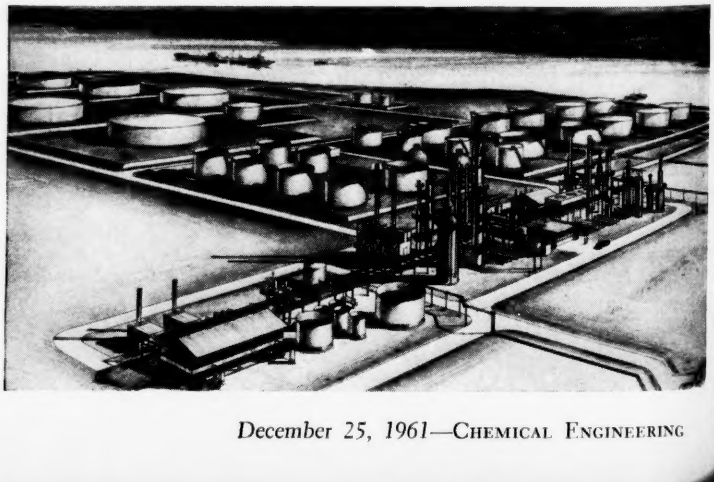
Over
rom
ecial
ted
lger
or a
om-
op.
es,

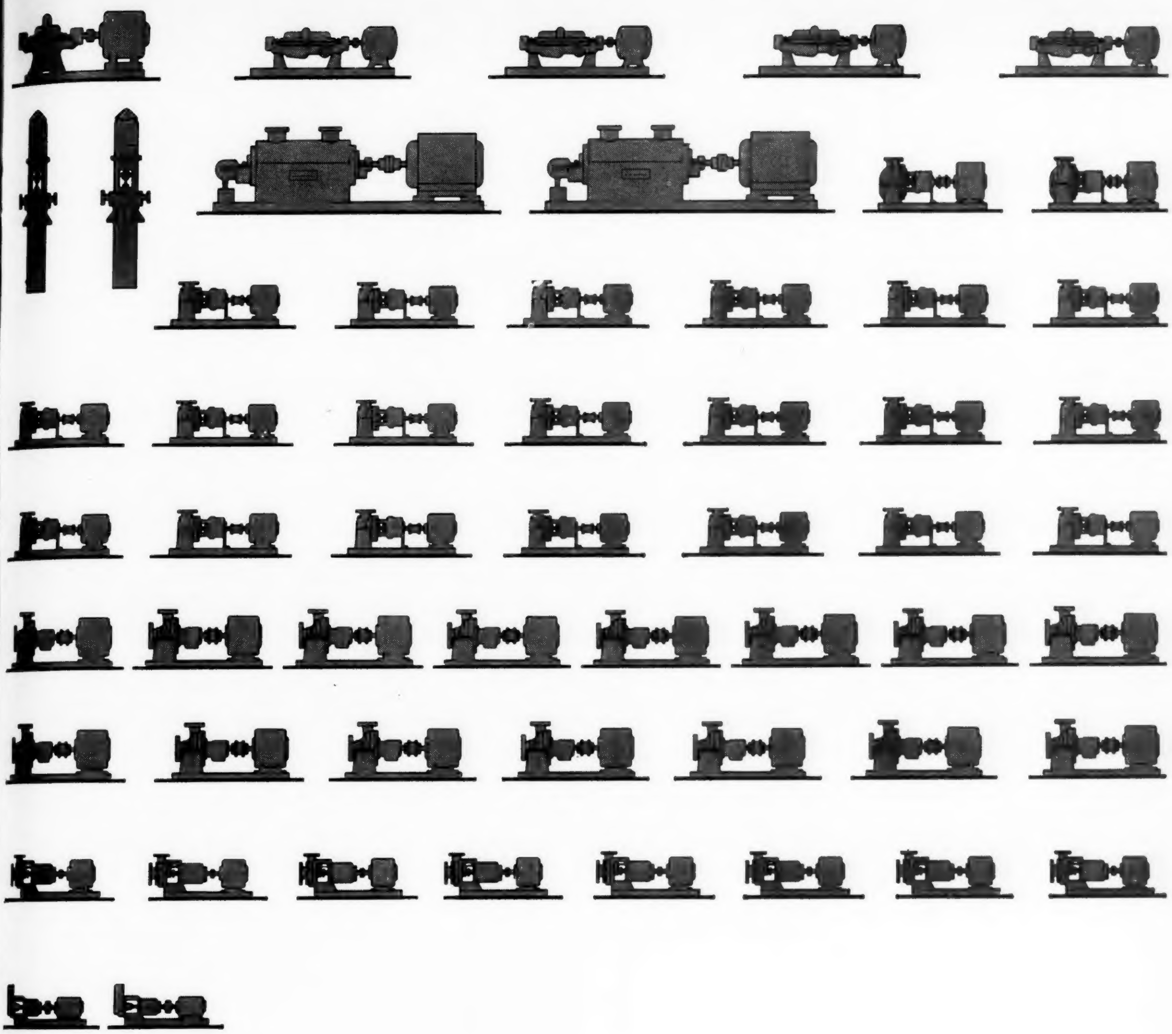




These 122 Ingersoll-Rand centrifugal pumps will

at new "grass-roots" refinery in F

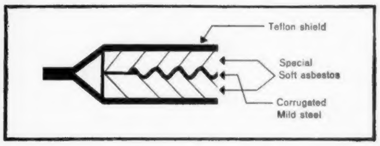




CRT gaskets now standard on Glasteel™ reactors

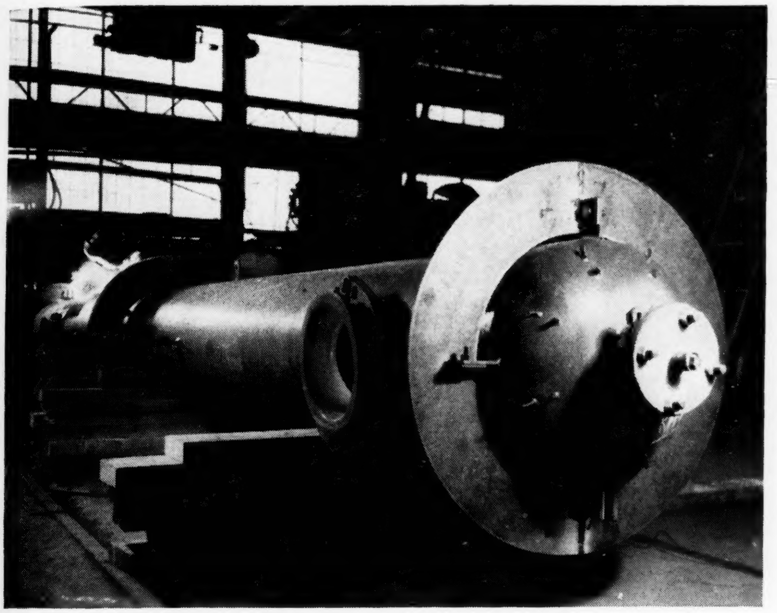
The old adage that a chain is only as strong as its weakest link has its counterpart in process equipment.

That's why we now provide our CRT gasket as standard with Pfaudler Glasteel reactors. With it you can handle corrosives to the maximum temperature limit of the vessel and pressures to 500 psi. This cross-sectional schematic shows you the CRT's construction.



The center core is thin, corrugated mild steel. It gives added strength. Extra-thick soft asbestos provides a spring action that keeps the gasket tight. Thus, little shimming is required. Naturally, the Teflon envelope has a very high corrosion tolerance.

You pay no more. You get the operating efficiencies of the CRT as standard on Pfaudler reactors and also on other equipment such as dryer-blenders and polymerizers. It makes good sense. That's what we strive for in all our equipment. Can we answer any questions for you? Write to the address shown at the bottom of this page.



What else is new with Nucerite?

This column is. It measures 18 inches in diameter and is 240 inches long. It will be used in a process where vapor-phase corrosion has been a problem in the 600°F. range.

This goodly sized column is additional evidence that Nucerite,* the new Pfaudler family of ceramic-metal composites, is increasingly taking the form of production-sized equipment.

Which brings us to more news. You can now get vessels in capacities up to 2000 gallons, for operations to 700°F, fashioned out of one of the many formulations of Nucerite.

The reason Nucerite is fast coming into its own as a material of construction is its unmatched ability to stand up to high-temperature corrosion (500°-1500°F), abrasion, and thermal shock.

It appears to be a practical answer for handling abrasive solids in aqua regia, digesting ores at high temperatures in acid solutions, reconcentrating acids, or handling corrosive vapors at elevated temperatures. Tested in sulphuric acid-recovery concentrators, Nucerite immersion heaters show little build-up of carbon; hence, good heat-transfer efficiency.

On a less spectacular—but still important level—Nucerite is proving itself in manhole extension collars on standard glassed-steel reactors. Both impact and abrasion resistance are the features for this application.

So, news continues to be made about Nucerite. Maybe you're next. Let us send you our data sheet that will put the proper sample in your hands. Ask also for Bulletin 999. It covers Nucerite's impact resistance; stability at high temperatures; tensile strength; resistance to abrasion, thermal shock and corrosion; and heat transfer.

*Patent applied for

Do not despair about evaporating "problem" products

Send for this booklet. It tells all about the Pfaudler® Wiped Film Evaporator —how and why it efficiently handles products that are heat sensitive, viscous, or low in thermal conductivity. Also, facts and figures on standard models with 4 to 100 sq. ft. of evaporating area. Test facilities provided for product evaluation. The Bulletin is 991. Free, of course.

Address all inquiries to our Pfaudler Division, Dept. CE-121, Rochester 3, N. Y. In Canada, contact Pfaudler Permutit Canada Ltd., Toronto.

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

Top news stories and what they mean to CPI technical decision-makers

Chementator

Reinforced-plastic pipe rolls out continuously, using novel mandrel

Cheaper reinforced-plastic pipe may result from a new manufacturing system that produces the pipe continuously in almost any desired length. This is done with a machine that not only can wind glass-fiber tape at any angle, but also can vary the orientation of the fibers from layer to layer to meet different types of stress.

Previous manufacturing operations have limited the length of pipe sections to the length of the mandrel around which the pipe is formed. In the system developed by Carlon Products Corp., Aurora, Ohio, continuous wrapping and curing is done by using a collapsible mandrel that is withdrawn from a finished length into a ready-to-be-formed portion of the pipe.

Although exact prices have not been established for the new product, Carlon estimates that savings of up to one-third may be possible compared with conventional reinforced-plastic pipe.

The continuously produced pipe can be used at 400 psi., has an upper temperature limit of 400 F. Burst pressure is 1,800-3,000 psi., depending on pipe I.D. A special liner can be used to eliminate weeping and increase burst pressure.

Available now in 2½-in. dia., the pipe will soon be made in several sizes from 2 to 4 in. Manufacture by the continuous process does not affect the corrosion resistance properties of this type of pipe.

Processing-for-hire picks up two more converts on the Gulf Coast

Two companies that are striving for self-sufficiency in raw materials have hit upon the same method for minimizing capital investment in new facilities. The device: renting excess processing capacity from another company.

Marbon Chemical, which has a major styrene project under way (*Chementator*, Nov. 27, p. 45), has arranged for Humble Oil to reactivate an idle butadiene unit at the latter's Baytown, Tex., refinery. Unit will be modified to allow dehydrogenation of ethyl benzene to styrene; Marbon will pay Humble on a fee basis for this service.

Technically, Marbon is receiving a 96% ethyl benzene stream from Humble's Enjay Chemical subsidiary. In practice, however, the ethyl benzene will flow directly to the dehydrogenation unit within the Baytown refinery. Crude styrene monomer will then be piped over the fence to Marbon's new plant for final purification. Thus Marbon will be able to turn out 75 million lb./yr. of styrene with a capital investment estimated at only $3-5 million.

In similar fashion, Monsanto Chemical is arranging to have an unidentified company produce acetic acid from ethylene that will be made at the former's Chocolate Bayou, Tex., plant. Monsanto will use the acetic acid as one of the raw materials for a 45-million-lb./yr. vinyl acetate monomer plant it is building at Texas City, Tex.

Trade sources indicate the other company is Celanese Corp. That firm is building a new acetaldehyde-from-ethylene unit at Bay City, Tex.; part of the acetaldehyde output could then be converted to acetic acid and returned to Monsanto.

Common monomers give unusual polymers via new catalysts

Registrants at the recent AIChE meeting in New York heard a few tantalizing hints about new polymers that may be forthcoming through the magic of stereo-specific catalysis. But like most polymer chemistry, details of these new European developments are cloaked in secrecy.

Norman Gaylord of Gaylord Associates, Newark, N.J., reported that one European company is readying plans to make "polyethylene" from propylene monomer. This seeming con-

tradiction is accomplished by an unidentified catalyst that activates propylene in the 1,3 positions. This leads to formation of a straight-chain polymer, rather than conventional polypropylene chains that have regularly spaced methyl side-groups. Advantage of this unusual route is that propylene is usually cheaper than ethylene.

A second development described by Gaylord is a new catalyst that activates styrene in the 1,6 positions—leading to polymers that have alternating ethyl and benzene groups in the backbone. Compared with conventional polystyrene that has the benzene ring as a side-group, the new polymer is said to have superior heat-resistance, softening-point and melting-point properties.

Herman Mark of the Polytechnic Institute of Brooklyn reported that new complex coordination-type catalysts can polymerize carbon-to-oxygen bonds as well as carbon-to-carbon bonds. This creates the possibility of polymerizing aldehydes and ketones to form polymers that are both polar and stereo-regular.

Main problem in polymerizing aldehydes and ketones has been the tendency of the polar groups to form stable complexes that prevent polymer buildup. This can be solved with new catalysts, says Mark, by reacting at high temperatures and choosing a solvent that competes with the monomer in formation of complexes.

Use of titanium lining for large reactor vessels, as well as for piping and smaller equipment, will make Celanese Corp.'s new acetaldehyde unit at Bay City, Tex., the biggest customer for Ti in the chemical industry. Wyatt Metal & Boiler Works, Houston, is handling fabrication.

Cost of new sewage plant is sliced in half by zeta-potential control

Promising to become widely used in controlling precipitation, zeta-potential measurement has just been given its first assignment in municipal sewage treatment. Thomas M. Riddick & Associates, New York, which designed the first water-treating plant employing this principle, is now putting it to use in a novel sewage plant design for the city of Norwich, N.Y.

Zeta-potential is a measure of the electrokinetic charge that surrounds suspended particles. If this charge is brought close to zero, coagulation of colloidal material is greatly enhanced. Development of a simple zeta meter for measuring the charge, and special cationic polyelectrolytes for controlling it, have made this a practical way to control sedimentation operations (*Chem. Eng.*, June 26, 1961, pp 121-126).

In the new sewage plant, wastes will be pumped to a flocculating basin, then agitated by rounded wood slats. It is in this flocculation step that zeta-potential is measured and controlled, thereby assuring essentially complete removal of solids during primary treatment. The liquid will then pass to an aeration tank for chlorination and oxygen make-up. The solids from the flocculator will pass to an aerobic digester.

Cost of the 8-million-gal./day plant will be $550,000. Riddick estimates that it would have been twice as high if the need for secondary treatment had not been eliminated by better flocculation through zeta-potential control. Based on a 16-yr. amortization, this means yearly savings of $35,000. Cost of the cationic polyelectrolyte will be about $15,000/yr., for a net saving of $20,000/yr.

Interest heightens in cleanup process for cracking catalysts

Though still chary with process details and economics, The Atlantic Refining Co. recently disclosed more about its new Met-X process (*Chementator*, Oct. 16, p. 92) for removing metal contaminants from petroleum cracking catalyst.

Met-X is based on ion exchange. Contaminated catalyst bleeds from the fluid catalytic-cracking unit and is slurried in water with a cation-exchange resin. After this contacting step, an undisclosed operation in a vertical column separates contaminant-loaded resin from the slurry. Then, catalyst is dewatered and dried for re-use, while a mineral acid regenerates the resin.

Atlantic has a 40-ton/day Met-X unit at its Philadelphia refinery, is using the facility to decontaminate catalyst from a cat cracker that can handle 30,000 bbl./day of fresh feed. Company expects the cleanup unit to bolster net income of the cracking operation by at least $1 million/yr.

Planning to license its process, Atlantic

(Continued on page 22)

New Honeywell Series 10/20 Millivoltmeters give you an easier-reading scale, and all the latest features for indicating, controlling and safety cut-off.

NEW HONEYWELL MILLIVOLTMETER LINE

gives wider selection . . . greater accuracy

The newly designed Series 10/20 provides accuracy of ±½%, plus all the latest features in millivoltmeters for indicating, controlling and safety cut-off. Wide selection of ranges and control units makes it easy to match the Series 10/20 to your specific process requirements. Extra-sturdy construction ensures accurate and reliable service even under severe operating conditions.

Here's what you get with the New Series 10/20 Millivoltmeters:

higher accuracy
Accuracy ±½%. High resistance measuring circuit minimizes calibration shifts due to changes in external resistance.

simplified installation
Dual-voltage transformers permit operation from either 115 or 230 volts. Dual tap connections make installation easy.

reads easy, reads right
Large, clear six-inch scale with anti-parallax mirror ensures easy, accurate reading.

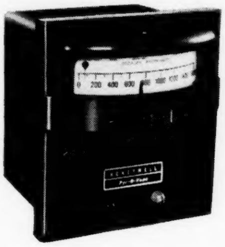
plug-in maintenance
True plug-in design enables you to replace major components in seconds.

high-brightness signal lights
Amber and red lights show at a glance the exact relationship between temperature and set point.

variety of ranges
A wide selection of ranges is available to measure temperatures as low as 325°F and as high as +3400°F within spans as narrow as 400°F and as wide as 3000°F.

thermocouple burnout protection
Process shuts down in event of thermocouple open circuit.

control forms to fit needs
There are 14 different control forms to give you exactly the control action you need: spst; spdt; sp3t with adjustable neutral; *Pyr-O-Vane* for electric on-off, two-position or three-position control; *Protect-O-Vane* for excess temperature cut-off with signalling or shutdown feature; *Pyr-O-Pulse* for pulse-proportioning control; and *Pyr-O-Volt* for current proportioning control.



for economy in less demanding applications . . .
HONEYWELL SERIES 10/10 MILLIVOLTMETERS

Here's a millivoltmeter line that's ideal for those applications where demands are less stringent, and where accuracy requirements are within ±1%. The Series 10/10 provides many of the design and construction features of the 10/20. It's the only economy millivoltmeter line with a full six-inch scale. These units are available in vertical cases only, with Pyr-O-Vane, Protect-O-Vane, and the new anticipatory Pyr-O-Pulse control units.

Get complete technical data and prices on the New Honeywell Series 10/20 Millivoltmeter Line by contacting your local Honeywell field engineer. Be sure to ask him about the economy Series 10/10. Minneapolis-Honeywell, 21 Penn Street, Fall River, Massachusetts. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

H *First in Control*

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world.
Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

points out that Met-X can yield three benefits:

• It eliminates need to purge contaminated catalyst, thus lowering fresh-catalyst demand to the replacement of attrition losses only.

• It allows refiners to crack more-contaminated stocks, thus allowing feed of heavier, higher-boiling streams to cat cracking. Conversely, use of Met-X allows an ordinary feedstock to be cracked into a more valuable slate of products.

• It can increase the capacity of a cat cracker by up to about 25%, because metal-removal will ease cracking's twin bottlenecks of coke formation and light-gases production.

In its own use of Met-X, Atlantic is initially aiming to cut requirements for fresh catalyst. But the firm also has plans to crack heavier stocks, and expects to eventually take advantage of the capacity increase that Met-X offers.

New method for removing alkyl mercaptans from cracked gasolines is on stream at Mobil Oil Co.'s Casper, Wyo., refinery. Gasoline is first mixed with air, then contacted with a caustic-cresylate solution containing 0.05-0.25% cobalt chelate. Cost of chemicals for this process is only half that of the conventional copper chloride route.

Metal boride is basis of long-sought breakthrough in aluminum making

Kaiser Aluminum & Chemical Corp. and British Aluminum Co. have announced joint development of an improved aluminum reduction cell that markedly increases production efficiency. Net effect of this and related research will be to substantially increase aluminum capacity in the U. S. with little increase in investment.

The modified cell is 15% more efficient than the conventional unit. This means that 1 lb. of aluminum can be produced with 15% less electric power, or that output can be increased using the same amount of input power. Both companies are currently operating the new cells on a test basis in commercial reduction facilities.

Only detail about the development given out officially is that the cell "utilizes refractory hard metals as essential elements." But the general outlines of the development are well known in the industry, and it is believed that all the major aluminum companies are working along similar lines.

Basis of the improvement is the substitution of either titanium or zirconium diboride elements for the usual iron bars that act as the cathode. Unlike the iron, which has to be protected from the corrosive molten aluminum and cryolite by several inches of carbon, the diboride can operate in direct contact with the reduction bath, thus increasing the current efficiency.

Another possibility receiving serious consideration is the use of refractory materials such as nitride-bonded silicon carbide to line the walls of the reduction cell (*Chementator*, Aug. 22, 1960, p. 52). Refractory producers such as The Norton Co., Worcester, Mass., have been actively working with aluminum producers on both aspects of cell improvement, and expect that a major market for borides and carbides will soon be opening up in the aluminum business.

"Who owns your knowledge?" plays big role in process secrecy lawsuit

Another battle over who owns an engineer's knowledge is shaping up in southern New York's Federal District Court. Du Pont is charging Von Kohorn International Corp., White Plains, N. Y., with illegally acquiring know-how on Du Pont's nylon and polyester processes.

Du Pont contends that Von Kohorn hired away Du Pont employees with the specific intent of learning process secrets. Du Pont further alleges that Von Kohorn then sold the processes to other companies and obtained patents, in several countries, based on Du Pont techniques.

Three technical employees are involved in the suit against Von Kohorn. Two quit Du Pont's Argentine affiliate, Ducilo Argentina, while a third went to Von Kohorn directly from Du Pont. The two workers leaving Ducilo are charged with taking drawings of equipment used in nylon production, while the third is said to have taken an operating manual on polyester production.

Although Du Pont alleges that the former employees took documents away with them, its complaint makes more of the fact that these employees had signed secrecy agreements when they went to work for Du Pont. The company's secrecy agreement is unusual in that it prevents employees from ever using or disclosing proprietary information. Most industrial secrecy agreements are not so broad, usually limiting the non-

disclosure period to 2-10 years (*Chem. Eng.*, July 28, 1958, p. 127).

A similar "forever" time clause in the secrecy agreement of Chas. Pfizer & Co. drew the fire of the Dept. of Justice as part of the department's action against Pfizer's dominant position in citric acid (*Chementator,* June 30, 1958, p. 47). No ruling has yet been forthcoming on the legality of this clause, however.

Among the points Von Kohorn makes in flatly denying Du Pont's charges: (1) it has never built a plant using any Du Pont know-how; (2) while Du Pont's continuous polyester process is patented, no patent infringement is claimed in the suit.

Esso Research & Engineering Co. has received a $50,000 contract from the U. S. Pubic Health Service to investigate foam fractionation as a way to remove synthetic detergents from sewage water. Method involves aerating the wastes, then skimming off the resulting foam.

Next goal for fluid-bed phthalic process: utilization of *o*-xylene

In a paper given before the New York meeting of AIChE early this month, Badger Mfg. Co. disclosed that it is working on a modification of its fluid-bed phthalic anhydride process that would make the route adaptable to *o*-xylene.

Badger indicates that to obtain this flexibility a second catalyst will be needed. This is in contrast to new types of fixed-bed phthalic catalysts that will give satisfactory yields with either naphthalene or *o*-xylene (*Chementator*, Nov. 13, p. 108).

Badger points out, however, that the catalyst in a fluid-bed unit is easily removed from the reactor. Units containing 50-100 tons of catalyst can be unloaded at a rate of 10-20 tons/hr. through a 4-in. transfer line, allowing complete catalyst removal in one shift.

As for economics of the modified route, Badger says that *o*-xylene would have to sell for 1¢/lb. less than naphthalene to make a catalyst shift attractive. Currently, the naphthalene-based process is said to be achieving yields of 95 lb. phthalic per 100 lb. of petronaphthalene, on a commercial scale. Total production cost, including depreciation, is 8.8¢/lb. of phthalic, assuming 6¢/lb. for naphthalene. And Badger expects the price of naphthalene to drop to 5¢/lb. in the near future, slashing production costs to less than 7.8¢/lb.

Besides operation at the original Sherwin-Williams plant, the fluid-bed process is now fully operable at two other plants in the U. S.: Reichhold Chemical's 30-million-lb./yr. unit at Elizabeth, N.J., and Hatco Chemical Co.'s 30-million-lb./yr. unit at Fords, N. J. In addition, Monsanto Chemical is going through shakedown runs at a 50-million-lb./yr. unit near Paulsboro, N. J.; and a 50-million-lb. unit is being built for Union Carbide at Institute, W. Va. that is due on stream in February.

All-plastic tanks drive for bigger stake in transport

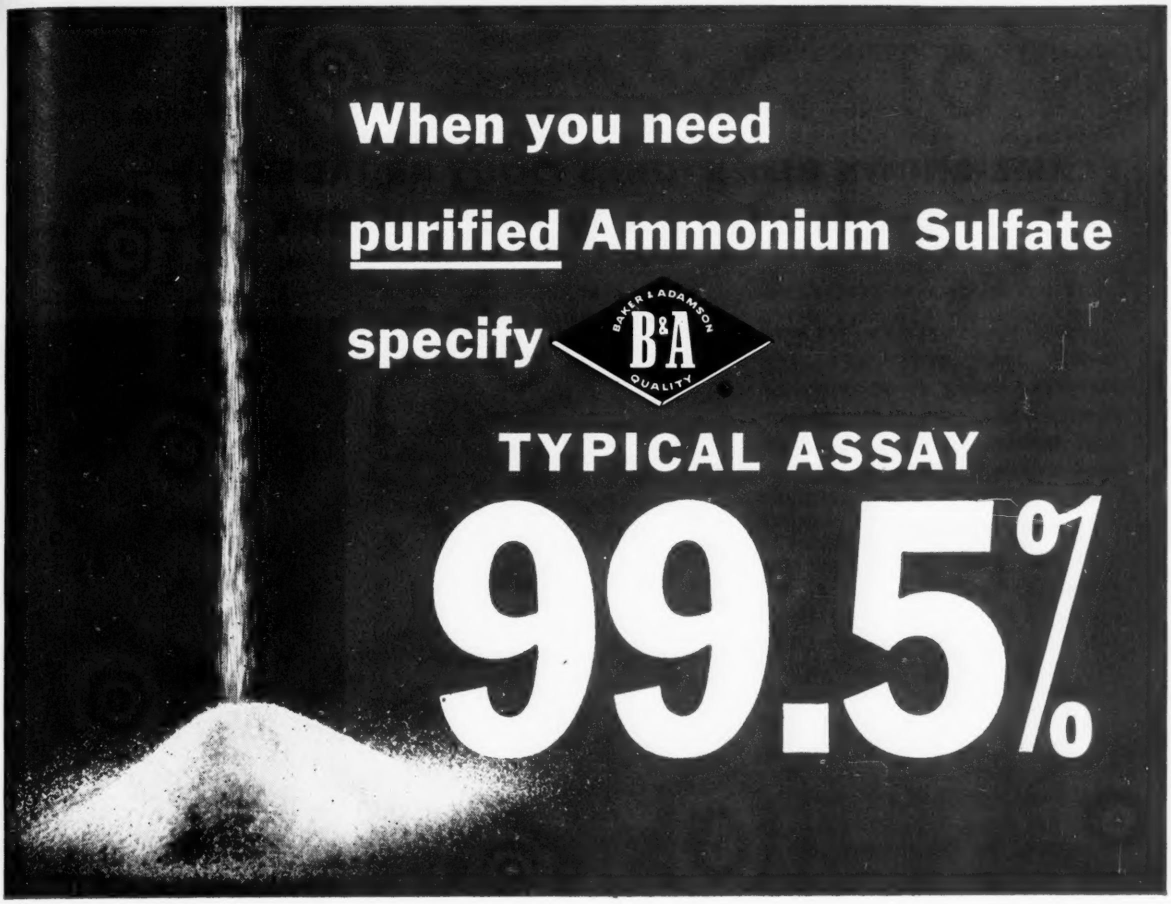
Signalling determination to win a bigger share of the 4,000-unit/yr. tank-trailer market, Haveg Industries displayed a 4,300-gal. all-plastic tank at the New York Chem Show last month.

The company already has about a dozen reinforced-polyester trailers on the road, most of which carry bleach and sodium hydroxide. For more-corrosive service, e.g., carrying chromic or fuming nitric acids, Haveg has patented a method for bonding rigid polyvinyl chloride to the reinforced polyester. The technique involves etching the PVC before bonding.

The company's eventual target is the whole broad spectrum of tank-hauled chemicals, which currently calls for about 1,500 new tanks per year. Within two years, the company expects a $1.5-million market. Advantages: plastic tanks average 25% lighter than those made of competing materials, permitting a corresponding increase in payload. Polyester tanks, according to Haveg, are competitive in cost with steel; PVC-polyester will run about $2/sq. ft. more than straight reinforced polyester.

Some other companies that have experimented with all-plastic tank trucks are not as optimistic as Haveg, however. They point out that unlined reinforced polyester cannot always be thoroughly cleaned after use. Often the contained chemicals impregnate the plastic slightly, limiting markets to those where this condition is no deterrent.

For More Industry & Economic News . . . p. 26



Ordinary commercial ammonium sulfate is a by-product. Not B&A *purified* grade. It is produced as a primary product, from carefully selected raw materials, to rigidly applied specifications.

You can tell the difference. Just compare the typical analysis given at right, with an analysis of the ammonium sulfate you're currently using. You'll see that the exceptionally low levels of iron, lead and arsenic in B&A ammonium sulfate provide the superior quality you need for high purity end products.

That's why B&A purified ammonium sulfate is preferred for manufacturing and processing foods and pharmaceuticals.

When you want to make the best, start with the best. In ammonium sulfate, as in so many other fine chemicals, that means B&A.

B&A® AMMONIUM SULFATE, PURIFIED

Typical analysis

Assay	99.5%
Insoluble	0.007%
Residue after ignition	0.01%
Chloride (Cl)	0.0005%
Phosphate (PO_4)	0.001%
Arsenic (As)	0.00002%
Heavy Metals (as Pb)	0.0002%
Iron (Fe)	0.001%

BAKER & ADAMSON®
Fine Chemicals

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Please send export inquiries to: Allied Chemical International, 40 Rector Street, New York 6, N. Y.

FLAME-GROWN GEM STONES ENJOY BROADENED USE IN OPTICS AND FASHION JEWELRY

Sapphire-encased rubies and black star sapphires are boosting sales of man-made gem stones, one of the chemical industry's most unusual and valuable products.

The $5,800* Christmas tree adorning the cover of this issue represents the output of one of the country's most unusual "chemical" plants: the multimillion-dollar crystal products facility of Union Carbide Corp.'s Linde Co. at East Chicago, Ind. This is the only plant in the U. S. equipped to turn out crystals of corundum (sapphire), spinel and titania in gem quality.

Two of the newest crystals to be announced by the company are a sapphire-encased ruby rod (for optical masers) and a "honey-black" gem (for jewelry). Industrial sales for electronics, semiconductors, optics, wear and polishing applications now make up the bulk of Linde's multimillion-dollar annual sales. But sales of gem stones for jewelry have been growing more rapidly—about 40% per year in the past three years—due mainly to the success of the star sapphires.

▶Masers: Unlimited Potential—Linde's single most promising new stone is probably the sapphire-encased ruby (*Chem. Eng.*, Oct. 31, 1960, p. 46). Used in optical masers, this crystal now accounts for 15% of the firm's industrial gem sales, even though this combination didn't exist 18 months ago.

The optical maser is essentially a light amplifier and is being researched intensively by organizations such as Bell Telephone Laboratories and Hughes Aircraft Co., for use in communications, physical research and military defense. Because the ruby crystal emits a beam of extremely high frequency (around 4.2×10^{14} cycles), it should be possible to impress vast amounts of information on a single beam—once researchers learn both how to operate a solid-state maser continuously and how to modulate the signal.

In telephone communications, it should eventually be possible to send messages on maser beams through underground conduits (to keep the light beam free from atmospheric interference). A single such beam would have the capacity to carry all of the present cross-country telephone traffic.

▶Light From Electrons—The maser overlay crystals have a ruby core, up to 0.08 in. dia. and 1.5 in. long, containing 0.05% chromic oxide. Sapphire overlay brings final dimension up to 0.20 in. o.d.

When operating as a maser, the crystal is surrounded by a helical-shaped xenon-arc "light pump." Light from the arc excites chromium atoms in the ruby to emit light of a specific frequency. Geometry of the crystal causes the light waves to be reinforced, so that a concentrated beam of parallel rays exits from one end.

The high refractive index of the sapphire (1.76) focuses light toward the ruby core and reduces heat absorption, increasing the intensity of the emission. Since equivalent temperature is 10^{10} K., it is possible to concentrate enough energy in these beams to punch holes in thin metal plate.

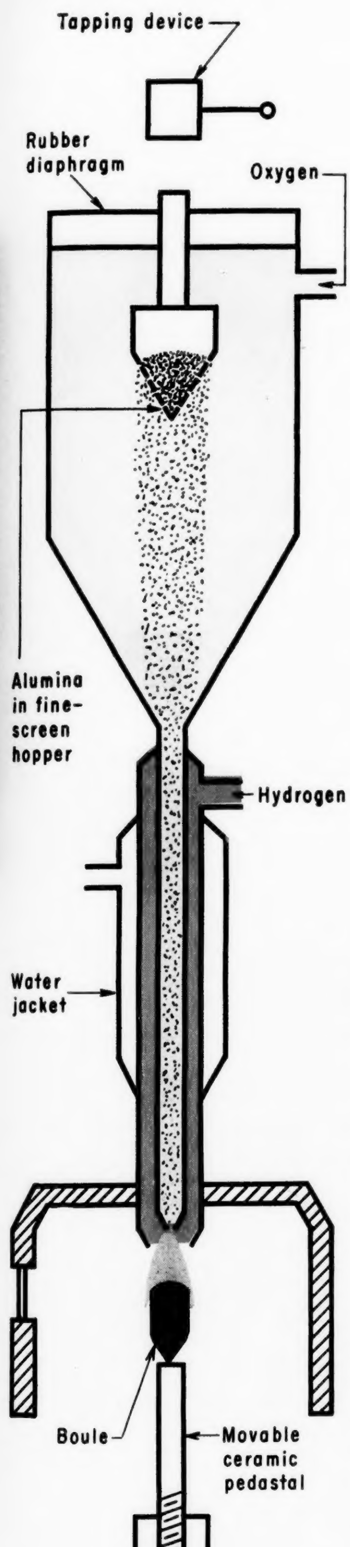
▶How They Are Grown—The maser crystals, as well as the rest of Linde's crystal output, are grown by highly refined versions of the 60-year-old Verneuil flame-fusion process (see diagram).

To produce the two-part maser crystal, ruby is first grown in the shape of an optical-quality disk, 5 in. in dia. Rods are machined from the disk and chemically polished to almost perfect cylinders. The polished rod is inserted in the chuck of a second furnace and rotated horizontally as the sapphire casing is applied. Finally, the combination crystal is annealed for several hours to reduce internal stresses.

▶Refining the Refinements—Optical-grade ruby must be of even

Intense 3,900-F. heat of an oxyhydrogen flame—converts powder to synthetic gems (photo above). Essential features of this process are shown in the diagram at the right. Pure alumina powder, containing proper coloring compounds, falls into the flame at a carefully controlled rate. Alumina melts, then deposits on a seed crystal supported on a pedestal that is lowered at a rate of about 1 in./hr. The crystal normally forms into a cone-shaped boule, 2-3 in. long and 1-in. maximum dia.

* Approximate retail value of the stones. Among those shown: synthetic star rubies; blue, black and white star sapphires; clear blue and white sapphires; and clear ruby, topaz, spinel, titania and aquamarine. See p. 6 for more details.



higher quality than ruby for gem stones. Besides maximum purity, the crystal must have total continuity, i.e., lack of polycrystallinity and "twinning," plus uniform dispersion of the chromium throughout. To obtain this high degree of crystal perfection, variables such as raw-material purity, flame temperature and crystal platform speed must be tightly controlled.

To prepare alumina powder raw material with less than 200-ppm. impurities, Linde first produces alum from ammonium and aluminum sulfate, then purifies via a three-step recrystallization. Pure alum is finally calcined to alumina.

Oxygen used in the furnace is 99.95% pure. And Linde refines its own hydrogen to 99.95% purity by using molecular sieves to adsorb hydrocarbons from a byproduct H_2 stream it purchases from a nearby Union Carbide Chemicals plant.

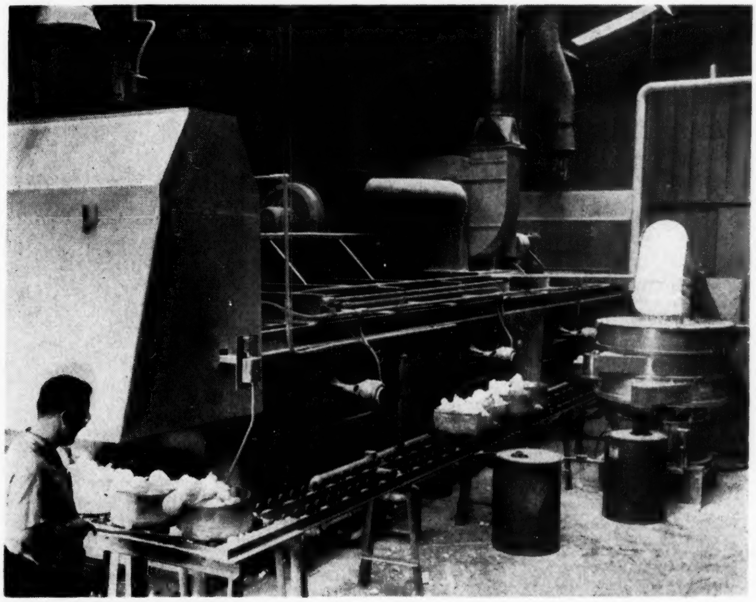
▶ **Control in the Furnace**—Close control of the oxy-hydrogen flame temperature is especially important for uniform chromium dispersion, since changes in temperature will alter the rate of chromium vaporization. The flame is controlled within 25 F. at about 3,500 F. by using sensitive optical pyrometers that regulate the flow rate and ratio of the oxygen and hydrogen feeding the burner.

Variables related to flame control and crystal withdrawal are all controlled automatically, so that for most crystal-growing the operators merely have to charge powder feedstock, turn on the furnace, then remove the finished crystal, or "boule."

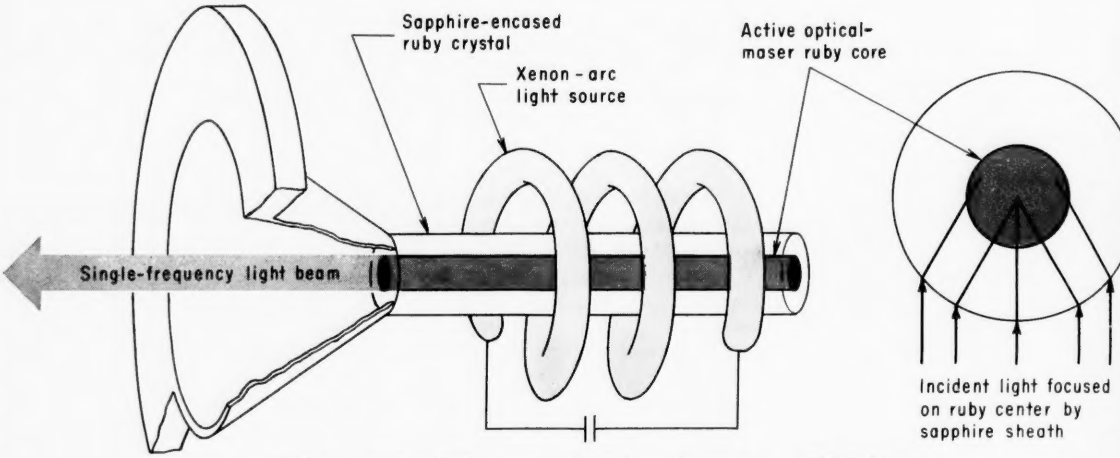
Linde has also had to develop improved lapidary methods (cutting and polishing) to meet the close tolerances on parallelism and end-flatness for optical crystals.

▶ **Selling to the Jeweler**—The making and selling of synthetic gems created many problems that are unique within Linde Co. and the Union Carbide organization.

First, the products are small-volume, high-priced items, unlike industrial chemicals. And there is much hand labor involved, especially in the cutting and polishing steps. Clear ruby boule can be produced for several cents per carat, for example; but a cut gem stone or an optical-grade ruby costs several dollars per carat because of the hand work needed. (Star boules cost



High-purity alumina is made by calcining alum in furnace at rear, then breaking up resulting "snowballs" (on conveyor) on vibrating screen at the right.



Ruby core of optical maser emits intense beam of parallel light rays.

Genealogy of Synthetic Gems

CORUNDUM: crystalline alumina (Al_2O_3). In its pure form, corundum appears as clear water-white sapphire. Ruby is merely corundum with several percent chromium oxide added; comparable quantities of titanium and iron oxides give blue sapphire. Salts of cobalt produce green; golden or topaz color comes from nickel and magnesium. Doping compound for the new black stars is still a secret.

Star sapphires and rubies form when less than 1% titania is added to the crystal as it is growing. A subsequent heat-treatment at 2,200 F. causes the titania to precipitate as fine needles along the crystal planes. After proper grinding, the accented crystal planes show up as a white six-pointed star when the stone is viewed under a point-source light.

SPINEL: crystalline magnesia-alumina ($MgO \cdot Al_2O_3$). Pure spinel is transparent and water-white. It can take on many colors, such as deep blue from cobalt oxide, and aquamarine from a complex mixture of nickel, cobalt, vanadium and titanium oxides.

TITANIA: tetragonal rutile form of titanium dioxide (TiO_2). This pale yellow stone, seldom found in gem quality in nature, surpasses diamond in brilliance because its high refractive indices (2.61 and 2.90) are higher than diamond's 2.41. Titania's Moh hardness, however, is only 7-7.5 compared with diamond's 10.

EMERALD: beryllium aluminum silicate ($BeO \cdot Al_2O_3 \cdot 6SiO_2$). All synthetic emerald processes are tightly guarded trade secrets. It's known, however, that emeralds can be grown from solution on a beryl seed crystal at elevated temperature and pressure.

about ten times as much as the clear stones.)

Finally, while selling of industrial stones can be accomplished on the basis of price and performance, marketing to the jewelry trade is much more complex because of the intangibles involved. There has been a built-in bias against anything "synthetic," even though most of the synthetic gems are more perfect from a crystal standpoint than are natural stones. (The primary way that experts tell synthetics from naturals: flaws are more pronounced and irregular).

As a part of its gem marketing program, therefore, Linde advertises directly to the consumer to combat the misconception that anything synthetic is necessarily inferior, an idea that has its roots in unfortunate consumer experience with synthetic materials during World War II. Linde doesn't sell its gems directly to the public, however. It works through three major gem distributors who sell in turn to jewelry manufacturers who mount stones in settings, then sell them to retail outlets for sale to public.—RAL

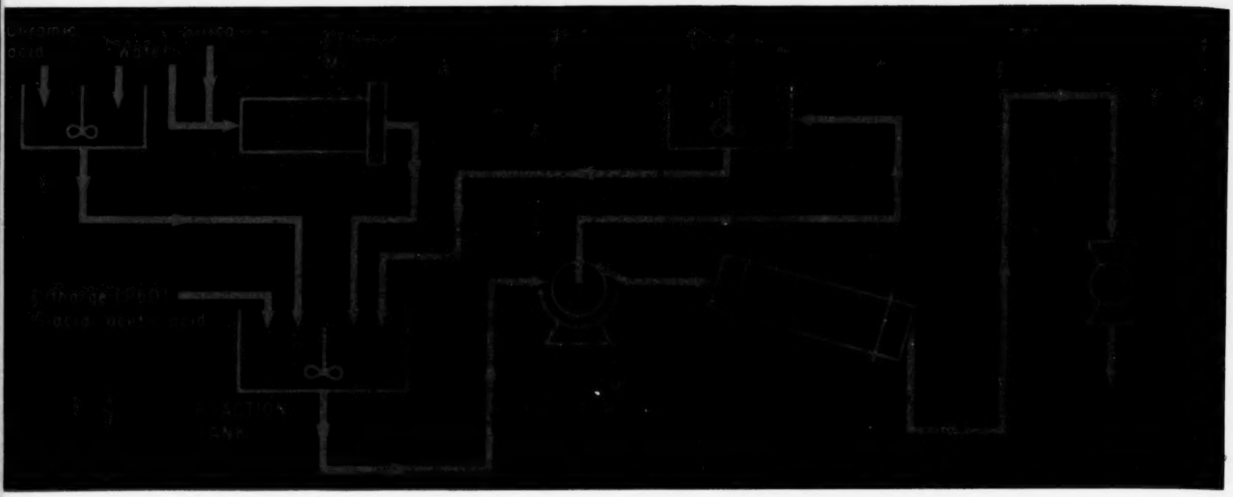
Broader Support Urged for Plastics Standards

A consideration of future profits alone should convince the U. S. plastics industry to participate more actively in setting of international standards for plastics. This is the opinion of Dow's W. E. Brown, voiced at the recent meeting of the American Standards Assn. in Houston.

Attacking a growing industry tendency to dismiss the value of international standards, Brown noted that although the U.S. had organized the Technical Committee on Plastics within the International Organization for Standards (see *Chem. Eng.*, Nov. 13, p. 210), there is growing sentiment for cutting back participation, because some companies can't see any immediate payout.

Charging that this is a shortsighted attitude, Brown cited several benefits to be derived from international standardization: (1) it helps shape uniform national standards; (2) it enables sellers to discuss specifications with buyers on a uniform basis; (3) it promotes product uniformity and thus boosts plastics usage; (4) it simplifies international exchange of technical information.

Brown pointed out that the U.S. stands to gain by leading in international standardization, and if this country loses the initiative, others are sure to fill the vacuum.



PIGMENT PROVES ITS RUST-FIGHTING PROPERTIES

Basic lead silicochromate pigment is backing its initial claims of exceptional anti-corrosion properties with results of service life tests over a three-year interval.

Having gained user acceptance for its special anticorrosion pigment, basic lead silicochromate, National Lead Co. is now taking steps to meet anticipated demand for the product.

Introduced commercially three years ago following extensive exposure tests at the company's Sayville, N. Y., and Perth Amboy, N. J., plants, the new product is outperforming older anticorrosive pigments in practical performance tests on the New York Triborough Authority's Throgs Neck Bridge.

Another two years will be required to complete the Authority's tests. However, its engineers are already convinced that the new pigment is superior to ones used previously. So National Lead executives foresee its adoption as the standard anticorrosive pigment for structural steel throughout the construction industry.

With this in mind, the company is installing a 170-ton storage silo for silica-flour feed material at its St. Louis plant as one step toward expanded output. This will permit receipt of the silica, an important ingredient of the pigment, in bulk freight cars instead of the presently used multiwall bags. Unloading and handling will be by air conveyors.

▶ **How It Came About**—Although red oxide of lead has been the accepted corrosion inhibitive ingredient of paints used on structural steel for many years, it has several major shortcomings. Most important: poor color stability, high specific gravity, high costs.

In an attempt to overcome the first limitation, National Lead researchers prepared a basic lead chromate by reacting 95 parts of 75% red lead with 5 parts of chromic acid. Ensuing product was found to be stable in color and to have corrosion inhibition equal to red lead when used in paint applied to structural steel. However, specific gravity of the new product was still high, and bulking value was low. Therefore, the pigment is subject to the same objection as red lead—high cost—which necessitates its dilution with lightweight, bulky materials, to the detriment of its effectiveness.

To overcome the high specific gravity, company researchers turned to a previous development, related to white lead for house paints—production of basic lead-silicate white lead. This product has a much lower specific gravity than conventional white-lead pigments, and thus requires only 60% as much pigment to give the same bulking value as the basic carbonates and sulfates of white lead.

Employing the same general technique as for the production of basic lead-silicate white lead, a coating of monobasic lead chromate was built onto the surface and chemically bonded to silica particles. The resulting product had corrosion inhibition equal to red lead, reduced specific gravity, and increased bulking value. Cost was reduced, since only 50% by weight was required to equal red lead in volume. Tinting value was also reduced, permitting the use of light-color finish coats.

▶ **Pigment Preparation**—The basic silicochromate is prepared by adding chromic acid solution to slurries of lead monoxide and finely ground silica, along with a small amount of basic lead acetate. The following reaction occurs:

$$2PbO + CrO_3 \rightarrow PbO \cdot PbCrO_4$$


precise
tubing

The slurry is dewatered and transferred to a rotary kiln where the lead monoxide reacts with the basic lead chromate to form tetrabasic lead chromate:

$$3PbO + PbO \cdot PbCrO_4 \rightarrow 4PbO \cdot PbCrO_4$$

As the temperature is increased in the kiln, the tetrabasic lead chromate reacts with the silica to form monobasic lead chromate and tribasic lead silicate, which combine physically, producing the lead chromate - lead silicate pigment on a silica core.

In the St. Louis plant, silica flour is ground for 20 hr. in an 8 × 10-ft. pebble mill to ensure uniformity of particle size (no more than 0.001% retained on a 325-mesh screen). Discharge from the mill is combined with litharge (PbO) and chromic acid in 10 × 7-ft. wooden reaction tanks that hold 3,000 gal. Critical point in the operation is control of litharge-chromic acid reaction.

Slurry from the reaction tanks goes to a vacuum filter for dewatering. Filter cake is screw-fed to a continuous rotary kiln operating between 1,100 and 1,200 F. Temperature of the kiln is carefully controlled by photoelectric units connected with two thermocouples. Readings are taken with each revolution of the kiln, as the couples dip into the bed of pigment.

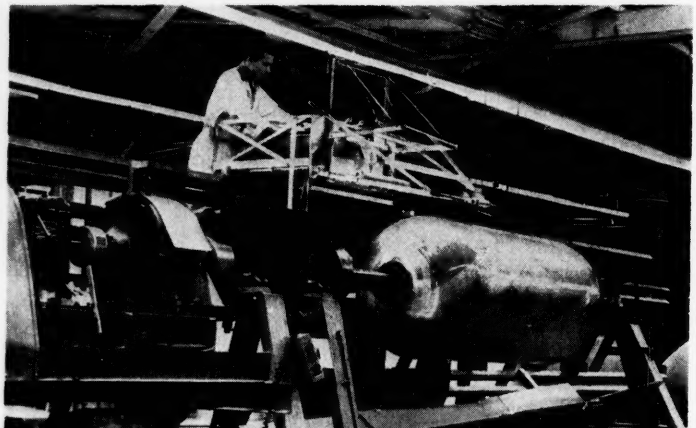
The calcined pigment is fed to a hammer mill, then bagged.

▶ **Other Family Members**—Since introduction of the basic lead silicochromate, National Lead has developed two additional silico pigments, each designed for a specific use:

Antimony silico oxide, called Oncor 23A, for flame retardance in halogenated resin compounds.

Lead silico titanate, called Oncor T 15, for improved tint retention through increased resistance and durability in tinted house exterior paints.—AVG

Filament winding to add more punch to Minuteman



Lamtex Industries, Inc., Farmingdale, L. I., has been awarded a contract in excess of $320,000 from Thiokol Chemical Corp., for development and manufacture of glass-fiber-reinforced epoxy casings for first-stage engines for the Minuteman ballistic missile. Casings will be 24 ft. long and 5.5 ft. dia., largest single-piece units ever produced by this method for rocket engines. Firm's Hystran winding process, shown above, controls tension and resin impregnation of each glass filament, rather than winding fibers in bundles as do most processes. Second-stage engines on the Minuteman already use plastic cases. The reason: filament-wound casings weigh only 37% as much as comparable steel units.

Simple Method Detects Water Contamination

To partially allay growing concern over water contamination, a simple test for determining presence of synthetic detergents has been devised by G. J. Crits, assistant technical manager of the Cochrane Div. of Crane Co. Although the test is specific only for detergents, presence of these materials in ground water may indicate that the water is also being polluted by bacteria and viruses from nearby sewers or cesspools.

Test is performed as follows: a tall cylindrical bottle, similar to an olive jar, is half-filled with water sample and stoppered. When the bottle is shaken, presence of high amounts of detergent will cause noticeable foaming.

Small amounts of detergents, although not foaming, will cause a thin film to travel up the side of the bottle. A ring measuring 0.375 to 1.5 in. high indicates presence of 0.3 to 3.0 ppm. detergents. Presence of acid will increase the ring height, however; so, for accurate results, the acidity of each sample should be adjusted.

Directory Tells Where To Go for Information

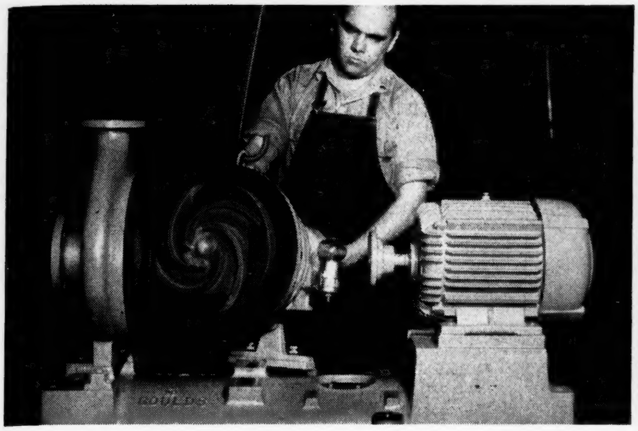
Engineers and scientists burdened with the problem of keeping up with the technical literature have been handed a new tool by the National Science Foundation: a directory of science information services.

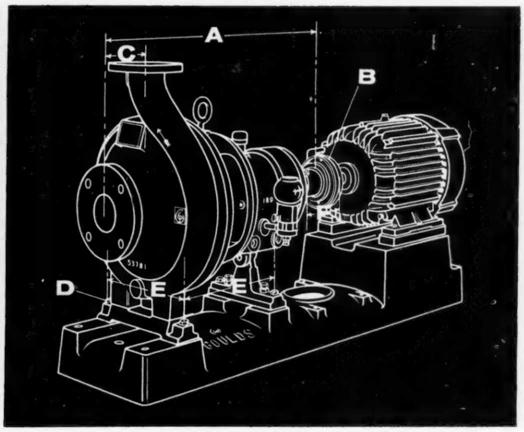
The publication lists 427 information centers that serve the needs of both scientists and engineers in the physical and biological sciences and technology. For each center listed, the directory gives a brief description of scientific specialization and type of service provided.

The 530-page book, entitled *Specialized Science Information Services in the United States,* is available for $1.75 from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

PUMPAGE

Goulds news about pumps for process industries





Standardized design features

Model 3195 gives you the greatest range of coverage and flexibility—with minimum parts needed—of any design on the market.

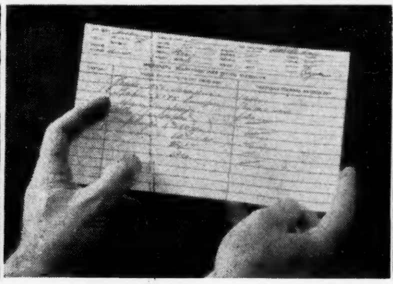
To meet varying service conditions, you can mount any one of the 11 pump ends to any one of three bearing frames (shafts $1\frac{1}{4}$, $1\frac{3}{4}$, and $2\frac{1}{8}$ through stuffing box). Nominal impeller diameters of 6″, 8″, and 11″ cover the range. Capacities to 775 G.P.M., heads to 300 ft. TDH. Handles liquids up to 500°F.

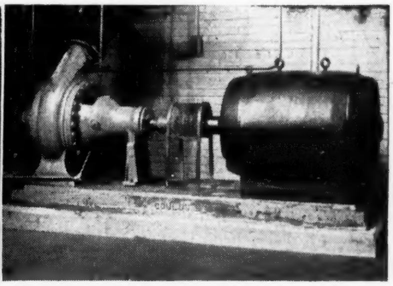
Dimensional interchangeability between all Model 3195 pumps

With this top-centerline, broad-coverage design, you can interchange pumps without making expensive piping changes. It has

- A One over-all length in all sizes........... 23″
- B One coupling fit for all sizes.......... $1\frac{1}{8}$″
- C One dimension end from suction to centerline of discharge.......... 4″
- D One bolt size for holding pumps to bases....... $\frac{1}{2}$″
- E One bolt spacing for holding all pumps to bases
- F One spacer coupling length for all sizes..... $3\frac{1}{2}$″

Back pull-out design lets you easily replace parts most subject to wear without disturbing pipe connections or motor mountings. For full information, write for Bulletin 725.1.





How to dewater a flood

Deep in a Virginia mine, water that could fast become a flood is being pumped out at as much as 8000 gpm for New Jersey Zinc Company.

More than a generation of miners has grown up since the first of the pumps started working. Yet these pumps, as well as the newer ones, perform so dependably that four more are slated to join them.

All 30 are Goulds single-stage, double-suction centrifugals. All use mechanical seals. All are grease lubricated.

Easy way to diagnose pump failure

Keep complete maintenance records on easy-to-use cards. Failures show chronologically, making it easier to get at the root of the trouble.

Cards are a help in ordering new parts, scheduling lubrication, and in determining pump suitability for new requirements due to process change.

Like a free supply of these pump maintenance record cards? Drop us a line. For information on this, or other products on this page, write Goulds Pumps, Inc., Dept. CE-121, Seneca Falls, N.Y.

Unique-alloy pump fights abrasives

The first pump in the system at Bestwall Gypsum Company's Pryor Mill works on a particularly tough service. It must handle bits of metal and glass the junk remover doesn't get.

It's a Goulds Model 3139 constructed of ISO-40.* This stainless steel alloy, highly resistant to corrosion and abrasion, has BHN hardness of 320 and tensile strength of 140,000 psi.

Do you have a similar severe application problem? Let us know. ISO-40 is available in several of our designs.

*Registered trademark of Empire Steel Castings, Inc.

GOULDS PUMPS

LINDE JOINS SELECT GROUP OF AWARD WINNERS

For an outstanding achievement by its chemical engineers who developed synthetic zeolite adsorbents, Linde Co., Div. of Union Carbide Corp., gets the 16th biennial Kirkpatrick Award at Hotel Astor banquet, November 28. Also honored, with Certificates of Merit, were the other finalist companies.

Congratulations to Linde President W. B. Nicholson (right) accompany unveiling of Kirkpatrick Award plaque by *Chemical Engineering* Publisher J. E. Tuohig.

Inventor of Linde's synthetic zeolite adsorbents, R. M. Milton (center) shares his elation over Award with R. W. Pressing, general manager, new products (left) and E. R. Behnke, manager, molecular sieves.

Award Committee Chairman M. S. Peters tells how the Committee selected a 1961 winner, after narrowing the field to five finalists. (Turn page.)

"Made OF Stainless Steel ...Made BY Jenkins"

Valve Performance Shows the Big Difference in that Spec!

When service conditions require valves of Stainless Steel, remember that metal is only part of the answer to long, dependable valve performance.

The WAY valves are made is equally important. Factors you can't even see make a big difference. Such factors as *perfection of castings . . . precision machining . . . painstaking inspection and testing . . . sound design.* Most important of all: *the maker's guiding policy about quality.*

To be sure about all these critical factors, experienced specifiers and buyers specify JENKINS as well as the metal alloy when Stainless Steel valves are needed. It is well-known that for almost a century Jenkins has made valves to *just one* standard of quality . . . the highest. At Jenkins every operation, every worker is aimed at fulfilling that standard, whatever metal a valve is made of.

SEND FOR NEW CATALOG 59-SS of Jenkins Stainless Steel valves in types and alloys to satisfy most needs. Jenkins Bros., 100 Park Ave., New York 17.

JENKINS

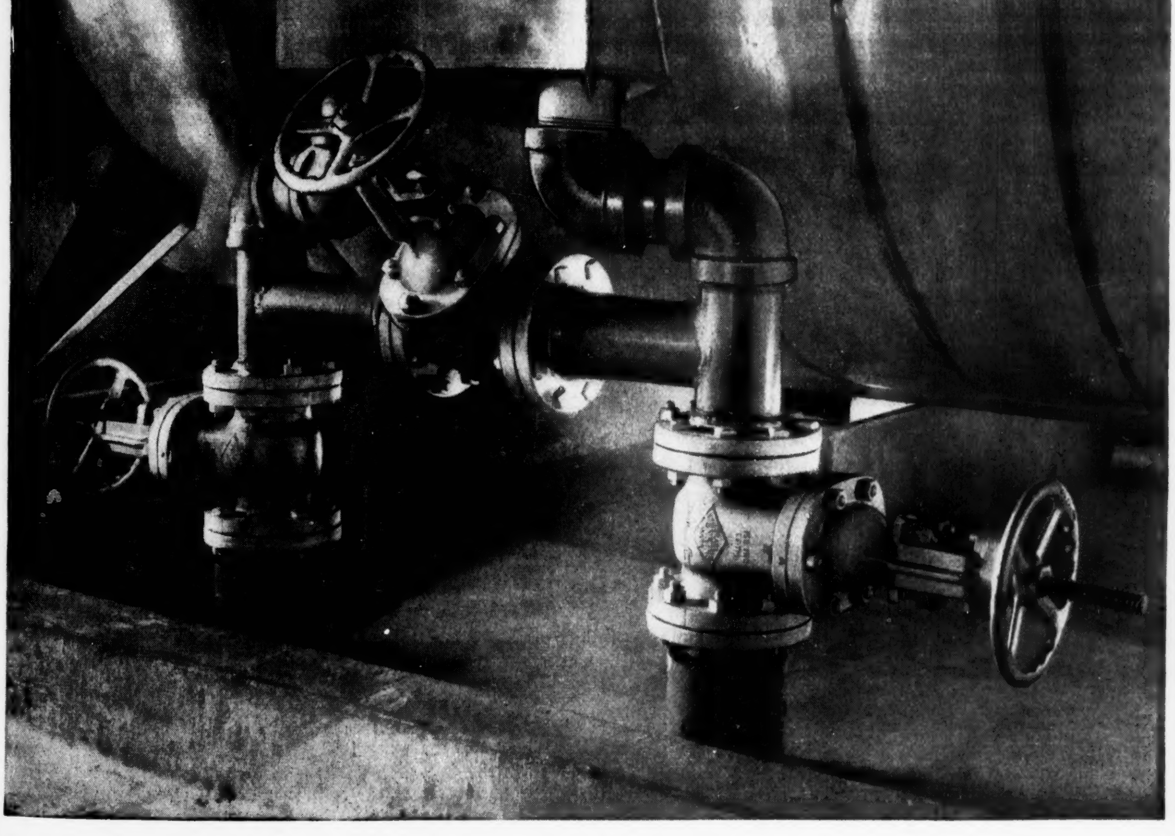
MOST TRUSTED TRADEMARK IN THE VALVE WORLD

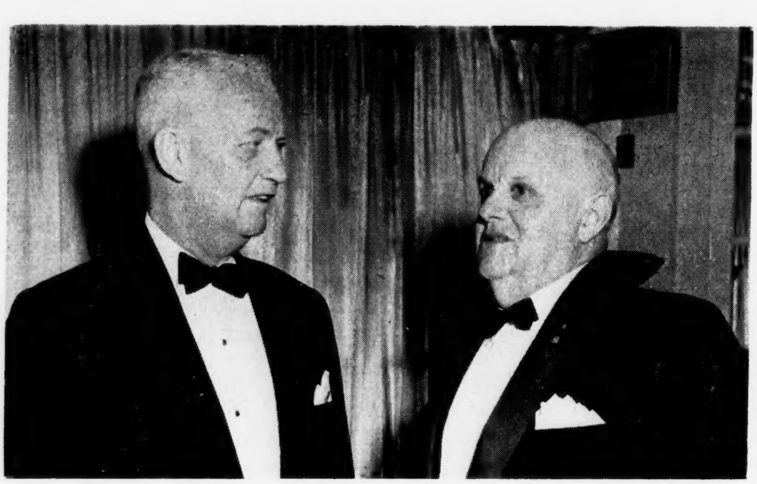
VALVES

JENKINS SINCE 1864

Jenkins Bros

A[illegible] Promptly — [illegible] Leading [illegible]



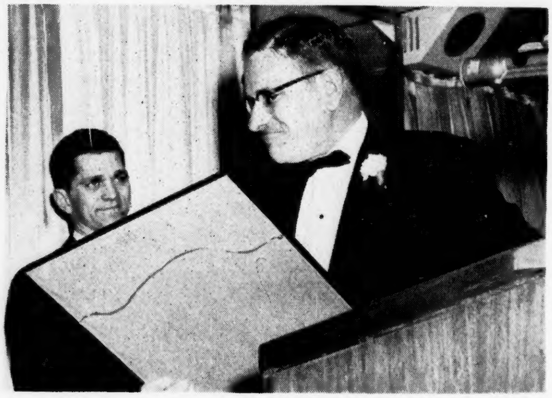


Featured speaker Admiral Arleigh A. Burke, USN (ret.), former Chief of Naval Operations and Chairman, Joint Chiefs of Staff (left), gets his briefing on the Award's history from Toastmaster S. D. Kirkpatrick.

Secretary C. H. Chilton of the Awards Committee reads citations that highlight achievements of all winners.

Other finalists get Certificates of Merit for chemical engineering achievements

Catalytic hydrodealkylation route to naphthalene, benzene: Ashland Oil and Refining Co., E. F. Wells, president.



Synthetic straight-chain primary alcohols from ethylene: Continental Oil Co., E. R. Baker, general manager, R&D.

On-line computer control of synthetic ammonia facility: Monsanto Chemical Co., W. M. Cooper, director of applied mathematics dept., research and engineering div.

Pioneer application of computer control to refinery unit: Texaco, Inc., T. A. Mangelsdorf, senior vice president; TRW Computers Co., D. L. McGurk, manager (left).

NEW EQUIPMENT AND MATERIALS VIE FOR CHEM SHOW ATTENTION

Over 500 exhibitors brought out their newest and best wares to draw the interest of visitors at the chemical industry's biggest spectacle.

Early this month, around 35,000 processing experts subjected themselves to the biennial rigors of the New York Chem Show, officially called the "Exposition of the Chemical Industries." Registrants uncomplainingly endured aching feet, jam-packed aisles and after-hour rituals in hospitality suites, in order to glimpse the latest in equipment, materials of construction and processing aids.

If you weren't able to tour the New York Coliseum in person, here are some of the developments:

Continuous blending in two new types of units was demonstrated by Patterson-Kelley Co., East Stroudsberg, Pa. The first, a solids-solids blender, consists of a series of V-shaped tubes connected in series. Feed is introduced at one end and passes gradually through the rotating unit, with some feed being constantly recycled as it moves from one leg of a V to the next.

Second mixer is a solids-liquid blending device embodying a rotating disk that throws solids outward to the sides of a conically shaped vessel. A whirling annular device spins out liquid in a wide band of foglike particles that contact the falling solids.

A prestressed, impervious-graphite-lined pressure vessel was introduced by Falls Industries, Inc., Solon, Ohio. Vessel is suitable for operation from 0 to 300 F., at full vacuum to 100 psi.; it is highly corrosion resistant and can be heated or cooled via a jacket that is rated at 50 psi. Nozzles can be added or relocated in the field.

Fansteel Metallurgical Corp., Chicago, and R. S. Corcoran Co., Joliet, Ill., have collaborated on an all-tantalum pump for corrosive liquids. With all wetted parts made of Ta, the unit can handle virtually any fluid except some sulfur and fluoride compounds. With the new pump, an entire flow circuit—including tubing, valves and heat exchangers—can now be made from tantalum.

High-temperature plastic pipe, made from Kynar vinylidene fluoride resin, was announced by Tube Turns Plastics, Inc., Louisville, Ky. Useful temperature range of the pipe is said to be −80 to 300 F., compared with limits of 215 F. for polyvinyl dichloride, and 250 F. for chlorinated polyether.

Principal uses for the pipe are expected to be in service above 200 F., for such corrosive fluids as hydrogen fluoride, hydrochloric acid, ferric chloride slurries, caustic soda, wet chlorine and chlorine dioxide, nitric and chromic acids, chlorinated aliphatic and aromatic solvents, nitrogen tetroxide and hydrazine in storable propellant systems.

Engelhard Industries, Newark, N. J., announced it has developed methods for producing fused silica in 3-ton blocks. Large blocks lead to fabrication savings of as much as 50% in fused-silica equipment liners, since sheets up to 50 in. long, 40 in. wide and 6 in. thick can now be made.

Among applications for fused-silica liners: in chlorination processes, acid towers, and mixing and storage tanks. Silica beams can also be fabricated to support tower packings, and disks up to 40 in. dia. can be cut for base plates.

Southwestern Engineering Co., Los Angeles, introduced a new 60-in.-dia. high-capacity vibrating screen separator with three-dimensional movement. Unit is claimed to have greater separating efficiency and higher throughput per square inch of surface than any other screening device. It handles wet or dry, fine or coarse, heavy or light material. Screen life is said to be unusually long; spacing frames and screens can be changed quickly. Lack of transmitted vibration allows unit to be set in place without special foundation.

Haveg Industries, Inc., Wilmington, Del., displayed a 4,300-gal. tank-truck body fabricated from glass-fiber-reinforced polyester. The vehicle costs about the same as a rubber-lined steel tank but weighs 25% less, allowing greater payload. Haveg has also developed a method for bonding polyvinyl chloride to the polyester, allowing this construction to be used for chemicals that would ordinarily attack polyester.

Zeta-Meter, Inc., New York, disclosed that its unique line of zeta-potential meters (*Chem. Eng.*, June 26, p. 121) is going to be used in municipal sewage treatment for the first time. The city of Norwich, N. Y., is said to be saving $500,000 in a new plant by eliminating need for secondary sewage treatment, instead is using zeta-potential control to optimize floc-treatment.

For more information about the last two developments, see *Chementator* in this issue.

Grain-Derived Alcohol Gets Capacity Buildup

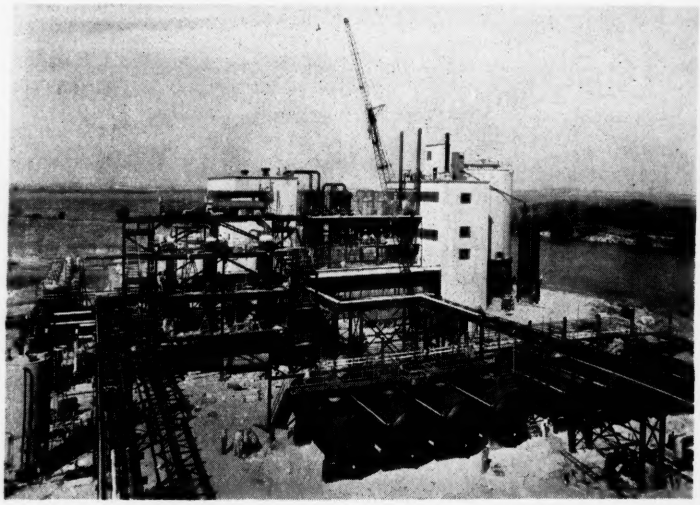
A new furfuryl alcohol plant, scheduled for completion in the first quarter of 1962, is being built in Omaha, Neb., by The Quaker Oats Co.

This will be the third such unit for the company (which is the only producer of the material in this country) and will double its capacity for the product. The new unit will also free some of the hydrogenation facilities at the firm's Memphis, Tenn., plant, allowing increased production of tetrahydrofurfuryl alcohol and other hydrogenated products.

The new alcohol plant will hydrogenate furfural from grain byproducts via a unique low-pressure process. Major use for furfuryl alcohol is in foundry-core binders, where in combination with urea it forms a fast-curing (10-20 sec.) hotset binder for sand molds. It is also being used in carbon-impregnating solutions and in binders for carbon.

Processes

Dixon etches niche in hydrofluoric acid ranks



Dixon Chemical Industries Inc.'s first step into fluorine chemistry is this 11,000-ton/yr. hydrofluoric acid plant at Paulsboro, N. J., making Dixon the twelfth U. S. producer of the chemical. Buss Ltd., Basel, Switzerland, provided basic plant design, technique, and assembly teams to help install critical process items. Unit will be integrated with Dixon's sludge-burning sulfuric acid plant on the 70-acre site.

Thick cadmium coatings, applied by a new vacuum-coating process, are being applied to high-strength alloy steel aircraft parts by a vacuum coater developed by NRC Equipment Corp., Cambridge, Mass. Vacuum metallizing with cadmium not only provides corrosion resistance but also avoids weaknesses introduced into steel by hydrogen embrittlement during conventional cadmium electroplating processes.

In the NRC process, cadmium is evaporated from special "boats" in a vacuum chamber via electrical heating. Cadmium vapor then condenses on the clean steel parts. Length of evaporation time, plus other variables, controls thickness of coating from 0.0002 to 0.0006 in.

Electrolysis of solid quartz can remove energy-absorbing impurities from quartz crystals so that they can be used in high-temperature resonators for frequency-controlling devices, reports Bell Telephone Laboratories. New crystals can operate as high as 1,020 F., compared with a limit of about 480 F. for conventional crystals. This could have special importance for electronic devices in missiles.

Bell's treatment consists of impressing an electric current at about 500 v. across a quartz crystal for about 24 hr. at a temperature of 930 F. Under these conditions, impurities such as sodium and lithium are swept out of the crystal, allowing it to vibrate at much higher temperatures, with little energy dissipation.

Plants

Borg-Warner Corp.'s Marbon Chemical Div., will build a 75-million-lb./yr. styrene plant at Baytown, Tex., adjacent to Humble Oil & Refining Co.'s refinery. Under the terms of a contract announced by Enjay Chemical Co., a division of Humble, ethyl benzene feedstock will be piped from the Humble refinery to Marbon. The latter will convert it to styrene monomer, ship that to its plastics-producing plants in Gary, Ind., and Parkersburg, W. Va. Construction at Baytown will begin by the end of the year, be completed early in 1963.

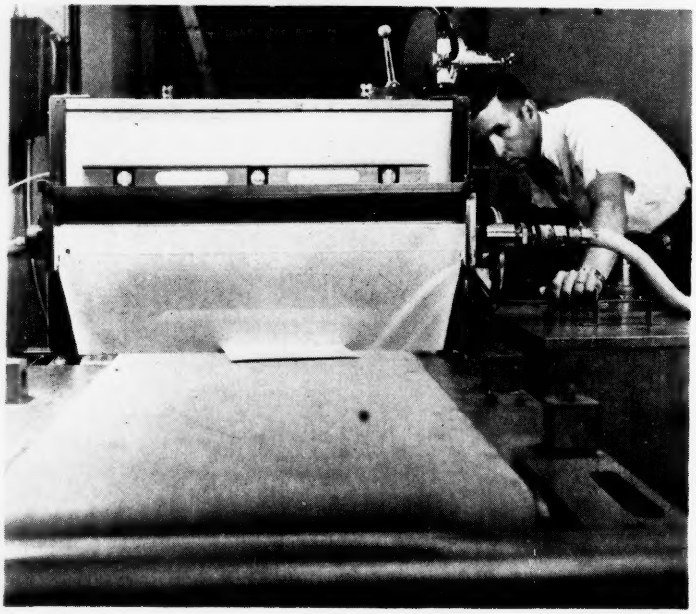
Texas Alkyls, Inc., a joint enterprise of Hercules Powder Co. and Stauffer Chemical Co., has quadrupled aluminum alkyls capacity at Houston. Original design capacity of the plant was 1 million lb./yr., but when the first unit came on stream in 1960, output was jumped to 2 million lb./yr.; now, facility can turn out 8-10 million lb./yr. Expansion adds a long list of aluminum alkyls (including isoprenyl aluminum, tri-*n*-butyl aluminum, diisobutyl aluminum hydride, diethyl aluminum chloride, methyl and ethyl aluminum sesquichlorides) to the two original products (triethyl and triisobutyl aluminum).

Freeport Sulphur Co. plans to add a second production platform to its enormous Grand Isle, La., offshore sulfur mine, 7 miles off the Louisiana coastline in the Gulf of Mexico. Already the largest steel island in the Free World, platform will measure 4,076 ft.—four times as long as the Queen Elizabeth—when the addition is completed in 1963. Goal: to drill 108 new sulfur wells in the ocean floor, 50 ft. down from the 1,500-ft. platform extension. To cost $3.5 million, addition will boost investment to a total of $30 million.

Tidewater Oil Co. plans a 32-million-cu. ft./day natural gas processing plant in Normanna, Bee County, Tex. Hudson Engineering Corp. will build the facility, beginning construction about March and planning completion in May. Design capacities: 63,000 gal./day of ethane-propane mixture, 15,000

CPI News Briefs continue on page 114

Paperboard gets polyvinylidene chloride coating



This sheet of bleached board is passing through a coater applying a thin but continuous film of Resyn 3600, a polyvinylidene chloride water-based system that imparts unusual barrier properties to paperboard surfaces.

The latex can be applied at low-coat weights on various substrates with curtain-coating equipment. Continuous films, easily formed at room temperature, will protect the substrate from strong acids, alkalis and most common solvents. When applied to paperboard products, Resyn 3600 also prevents transmission of moisture, gases and greases.—**National Starch and Chemical Corp., New York.** 42A

Epoxy lacquer

"One-can" epoxy systems hinge on the resin's long polymer chain.

Last month, at the Paint Industries Show in Wash., D. C., Shell Chemical Co. introduced the first epoxy resin that doesn't require any catalyst during cure.

It is a standard epoxy formed by reacting bisphenol-A and epichlorohydrin. Yet, without cross-linking, it can form coatings of unusual adhesion and toughness because it has the longest polymer chain (average mol. wt. 200,000) of any epoxy available.

Called Eponol 55, the compound can only be used as a lacquer. Dissolved in a suitable solvent, it forms a coating by solvent evaporation alone. The high bonding power of the resulting lacquer film comes solely from the resin's high molecular weight and linearity.

Shell reports that coatings made with Eponol 55 have outperformed vinyl, chlorinated rubber and nitrocellulose lacquers. Hardness, flexibility, abrasion and chemical resistance are typical properties of the new system. Single coats, either clear or pigmented, are often all that is required for protection of metal products.

Two solutions are presently on the market: Eponol 55-B-40, containing methyl ethyl ketone, and Eponol 55-L-32, containing Cellosolve acetate. They are aimed at the automobile market, but these lacquers will also be available in aerosol cans at retail stores. Both sell for about 50¢/lb.—**Shell Chemical Co., New York.** 42B

Dyeing aid

Water-soluble liquid is effective in dyeing nylon and wool.

Lanamol CW, a clear, viscous liquid with acidity at pH 4, is a new dyeing aid for wool and nylon fabrics. Soluble in water in all proportions, this product boasts excellent wetting qualities and dye penetration even upon shrinkage.

Application is simple. For dyeing wool, Lanamol CW is used with ammonium sulfate in a neutral or weak acidic bath (pH 4-6). Scoured wool is wet out completely in a bath containing 1% Lanamol and 1-3% ammonium sulfate or acetate. The desired dye is then added as a solution into this bath and the temperature is slowly raised to the boiling point for ¾-1 hr.

A similar procedure is used for dyeing nylon 6 and nylon 66. Here, the scoured fabric is wet out for 5 min. After the dye is added, 1-3% Lanamol CW and 10% ammonium sulfate are mixed into the bath, which is first run cold for ½-hr. and then slowly heated to boil for about 1 hr.

Product is reported to offer full and level dyeing, and complete dye exhaustion. Because of its freezing point of −15 C., Lanamol can be safely shipped and stored during winter months.—**Allied Chemical, National Aniline Div., New York.** 42C

Acrylic coating

Thermosetting finish cures rapidly under intense infrared radiation.

Curable in as little as 24 sec. with specially designed infrared heating equipment, Duracron promises excellent resistance to chemical corrosion and weathering.

Under normal conditions, such an acrylic polymer would have to

be cured for 30 min. at 350 F. in an enclosed gas-fired convection oven or receive 60-70-sec. exposure to 650-F. air. But exposing the organic coating to infrared radiation (wavelengths from 2-4 microns) can cut curing time to 24 sec. without affecting coating properties.

Chemically, Duracron is a coating composed of an acrylic compound (to which side-chain amides have been attached) copolymerized with styrene and ethyl acrylate. The polymer system is suspended in an aromatic solvent mixture of butanol, xylene and toluene.

Duracron coatings can be applied to metal siding, metal wall partitions, curtain walls, metal cans. It can also be used as an automobile enamel that, unlike other enamels, can be buffed and polished to remove blemishes from the painted surface. Resistance to chipping is claimed to be high.

In coatings on metal siding or strips, costs for Duracron are about 0.8¢/sq. ft. — **Pittsburgh Plate Glass Co., Pittsburgh.** **42D**

Germicide

Anhydrous new germicide in liquid form also acts as deodorant.

Hyamine 3500, a straw-amber liquid consisting of an 80% solution of alkyl dimethylbenzyl ammonium chloride in ethanol, is reported as an exceptionally effective germicide in hard water.

Miscible in all proportions with water, ketones, lower alcohols and glycols, this compound goes into the preparation of liquid disinfectants used in homes, hospitals and food processing plants. Because of its anhydrous nature, Hyamine 3500 can be incorporated in floor oils and waxes. Other possible applications include germicidal air filters and aerosol sanitizers; algaecides and slimicides for swimming pools, industrial water reservoirs, and water-cooled heat exchangers.

The product is partially soluble (30%) in aromatic hydrocarbons, and can be coupled into aliphatic hydrocarbons by a suitable dissolving agent such as imidazolium bromide. Density is 7.75 lb./gal., and the product is sold at 45½¢/lb. in tank-car quantities. Hyamine 3500 will crystallize after prolonged storage at low temperature, but will return to the liquid state at room temperature. — **Rohm & Haas Co., Philadelphia.** **43A**

Polyesters

Family of six resin formulations fills widely varying demands.

Six polyester resins of the same family—Selectron 5119, 5834, 5158, 5084, 5872, 5875—have been introduced to fill generally similar, but individually slightly different, specifications. Sparked by the promise of widespread polyester use in glass-fiber-reinforced vessels, all six are tough, corrosion-resistant, moldable, single-additive formulations.

▶**Selectron 5119** — The general-duty standby of the series, #5119 fills needs of several applications. Gel time is flexible. The product cures at room temperature, but also cures at uncommon extremes, which may depend on the thickness of the layer applied, gel time, catalyst concentration, and other factors (sample cures: 7 min. at 220 F.; 60 days at 77 F. and 0.2% catalyst; 72 hr. at 77 F. and 2% catalyst).

Glass-fiber-reinforced sections can be molded from #5119 with no pressure, slight pressure, or up to 10-15 psi. (as in bag molding). Closed molds may be used, or molds with one surface exposed to the air.

Selectron 5119 wets glass fibers but is sufficiently viscous to hold runoff to a minimum on vertical surfaces. It cures to a hard, tough, tack-free, rigid material that can be handled and sanded—in some cases, within an hour after gelation. As a general rule, a temperature hike of 18 F. cuts gelation time in half and an 18 F. temperature drop doubles it. Recommended catalyst is methyl ethyl ketone peroxide.

▶**Selectron 5834** — Retaining the basic characteristics of #5119, Selectron #5834 adds the property of thixotropy—the ability of some gels to become fluid when shaken, a reversible change. Its thixotropic property makes for easy application on vertical surfaces and over difficult mold contours.

A low-viscosity polyester, #5834 exhibits a wide range of gel times, minimum of drainage from impregnated mat and cloth in vertical positions, excellent uniformity of gel and cure properties, and the absence of spotting in a thick laminate that uses up to 0.5% catalyst concentration.

▶**Selectron 5158** — A moderately reactive and fast-curing molding resin, #5158 has exceptional impact and modulus properties. Excellent wet-strength retention and good weathering characteristics are coupled with crack-free moldability and surface gloss. Not recommended for room-temperature curing, it may either be molded as

Newsworthy Chemicals

Page number is also reader service code number

For more details use Reader Service Card

is or thinned with up to 15% styrene. Catalyst is benzoyl peroxide.

▶ **Selectron** 5084—Designed for long tank life with minimum drifting tendency, #5084 has an extended gel state during which it remains soft, flowable, fusable. Featured applications include rod stock, flat-paper-base laminates, preform molding.

▶ **Selectron** 5872—An opaque white gel-coat resin, #5872 was designed specifically to provide reinforced-plastic products with a tough, durable and attractive surface. Gel coats show excellent weatherability and heat-resistance. Product may be brushed on, although a spray system is recommended. Suitable spray conditions are pot pressures of 25-50 psi., atomization pressures above 50 psi. Catalyst is methyl ethyl ketone peroxide. Again, gel times are flexible.

▶ **Selectron** 5875—A neutral gel-coat resin, #5875 may be pigmented with one of several Selectron color concentrates for reinforced-plastic products with tough, durable and attractive colored surfaces. Like #5872, this one may also be brushed on although spraying is preferable. Spray conditions duplicate those of #5872. **—Pittsburgh Plate Glass Co., Pittsburgh.** 43B

Lubricant

Lowest friction is achieved by combination of MoS_2 and Teflon.

Lockrey Co. has just introduced a lubricant that successfully combines MoS_2 and Teflon, two of the most slippery substances known.

Marketed under the trade name Molynamel E, the lubricant can be dipped, brushed or sprayed on any surface with or without primer. The resulting coating — which dries overnight at room temperature — has an extremely low coefficient of friction, and is unaffected by most solvents except esters and ketones. The room-temperature cure is in contrast to the 600-700 F. bake normally required to fuse a Teflon dispersion coating.

Molynamel E may be applied to metals, wood, rubber, plastics, ceramics and glass. For carrying heavy loads, coatings may be baked with lamps or in an oven at 300 F. for 1 hr., or at lower temperatures for longer exposure periods, depending on the heat that the substrate material will stand.

Test have shown that lubrication action is continuous from 400 F. down to the cryogenic region. Adhesion and resistance to wear and corrosion are better than Teflon alone. Also, the product maintains its lubricating action under extremely heavy loads because of Teflon's tendency to fuse and redistribute itself, and molybdenum disulfide's load-carrying ability of 250,000 psi. **— Lockrey Co., Southampton, N. Y.** 44A

For more information about any item in this department, circle its code number on the Reader Service Postcard (page 145)

Readers' choice

Reader service inquiries provide a handy guide to new chemical items that most interest you, the reader—and an unpredictable group you are. To let you know which chemicals interest you most, the ones that were rated tops by you over the past year will be featured in a special roundup in this department next issue.
—ED.

Polyethylene

Plastic piping becomes stronger, can be extruded faster.

A new high-density (0.956) polyethylene, Bakelite DGDB-3044, is now compounded specifically for pipe extrusion. Because of a low melt index of 0.2, this polyethylene is extruded 10% faster than other high-density grades, and offers long-term burst strength. (Pipes tested at room temperature for 1,000 hr.—at hoop stresses of about 1,700 psi.—showed no evidence of failure.) Approved by the National Sanitation Foundation for transportation of potable water, DGDB-3044 pipe displays glossy internal and external surfaces. Free from scale buildup, the pipe is resistant to most corrosives as well as to rupture from freezing. The plastic's brittle temperature is −98 C.

According to the manufacturer, the pipe is flexible enough to allow easy coiling, and strong enough to withstand rough treatment during installation and service.**—Union Carbide Plastics Co., New York.** 44B

Briefs

Diheptyl p-phenylenediamine is the latest sweetening catalyst and gum inhibitor for gasoline. Called Tenamene 4, this amine compound sells for 83¢/lb., and when used at a concentration of 5 lb./1000 bbl. of gasoline, is particularly effective in lowering the mercaptan sulfur content. It also delays formation of insoluble polymers and gums that come from oxidation of unsaturated hydrocarbons in stored gasoline.**—Eastman Chemical Products, New York.** 44C

Epoxy plasticizer, Flexol GPE, combines the heat and light stabilization characteristics of epoxy plasticizers with the low-temperature flexibility and compatibility that are needed in vinyl plastics. This product is reported economical for vinyl producers because it can be used at about the same concentrations as higher-priced epoxy esters and adipate plasticizers. Flexol GPE has a price range of 31¾—34¾¢/lb. **— Union Carbide Chemicals Co., New York.** 44D

Crystalline silica, tradenamed Min-U-Sil, is a high-purity material used as filler in silicone rubber, epoxy and polyester resins, paints, cements, cleansers and polishes. It can also replace conventional silica in vitrified ceramics, increasing the strength while reducing the weight of ceramic ware. The new silica is available in 5-, 10-, 15- and 30-micron size. **—Pennsylvania Glass Sand Corp., New York.** 44E

TYPICAL PROPERTIES OF SHELL TOLU-SOL THINNERS

Tolu-Sol	5	10	15	20	25	30	35	40	45	50
Distillation °F. (ASTM D-86)										
IBP	199	199	199	199	200	203	204	204	205	205
Dry Point	215	217	220	222	223	227	228	230	230	231
Specific Gravity 60°/60°F.	0.699	0.714	0.721	0.729	0.734	0.747	0.751	0.761	0.769	0.785
Composition, %v										
Paraffins	88	82	77	73	69	64	60	56	51	46
Naphthenes	9	8	8	7	7	6	6	5	5	4
Aromatics	3	10	15	20	24	30	34	39	44	50
Absolute Viscosity centipoise @ 77°F.	0.41	0.41	0.41	0.42	0.42	0.43	0.44	0.44	0.45	0.46
Aniline Cloud Point °F.	148	134	123	114	107	93	86	75	64	55
Nitrocellulose Dilution Power* (ASTM D-1134)	1.22	1.32	1.40	1.49	1.53	1.62	1.68	1.76	1.84	1.92

*Also known as Lacquer Dilution Ratio

Comparison chart shows how range of solvency of Tolu-Sol family widens the choice of diluents for your formulations. *If an intermediate grade is needed, ask Shell to make it for you.* For help in choosing the grade that gives the optimum combination of properties and cost for your formulations, call in your Shell Industrial Products Representative.

BULLETIN:

Shell announces a large new family of Tolu-Sol thinners that allow you to choose the precise solvency you need

From today, the name Tolu-Sol® applies not to one product, but to a complete family of hydrocarbon solvents.

Shell's new Tolu-Sol family is characterized by extremely low naphthene content and closely controlled aromatic content. The family has a wide range of solvent power—but similar volatility. Here are the facts.

Now you can select precisely the right solvency for your needs from a family of thinners with similar volatility but different solvent power.

Shell makes this flexibility possible with its new Tolu-Sol family.

The composition of these thinners is characterized by a low naphthene content and a closely controlled aromatic portion. Within the family, the aromatic content varies from less than 5 per cent to about 50 per cent.

How to identify each grade

The percentage of aromatics identifies the grade of Tolu-Sol. Thus, Tolu-Sol 10 contains approximately 10 per cent aromatics. Tolu-Sol 50 has approximately 50 per cent aromatics.

The Tolu-Sol you have known for years is now called Tolu-Sol 25.

TOLU-SOL BULLETIN (CONT.)

And it now has a higher aromatic content and better odor.

To develop this new family of solvents, Shell scientists adopted a manufacturing technique that gives more precise control over the composition of each of the Tolu-Sol grades.

Controlled composition

The naphthene content is kept low, because naphthenes, despite their high KB numbers, have relatively poor viscosity reducing power. However, aromatics have high solvency and good viscosity reducing power.

Shell carefully controls the proportions of aromatics in each grade of Tolu-Sol.

Aniline cloud points and lacquer dilution ratios show that the Tolu-Sol diluents will provide the solvency you expect.

Scientist in Shell Laboratory measures lacquer dilution ratios of Tolu-Sol. Ratios range from 1.22 to 1.92.

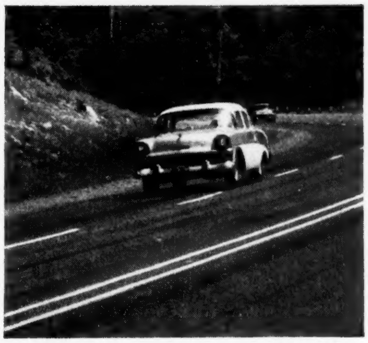
Greater uniformity

The Shell manufacturing technique produces thinners with dependable properties.

This new Tolu-Sol family can give you greater flexibility in establishing your own formulations.

Here, Shell discusses four important features of the new Tolu-Sol family.

1. *Compatibility.* The full family of Tolu-Sol thinners covers a wide range of solvencies (see chart). Aniline cloud points range from 148°F. to 55°F.



Range of solvencies of new Tolu-Sol family covers wide range of formulation requirements. Example: Low-aromatic Tolu-Sol 10 is ideal thinner for traffic paints and rubber cements.

and lacquer dilution ratios range from 1.22 to 1.92.

2. *Volatility.* The Tolu-Sol family has similar volatility with only small differences in evaporation rates.

3. *Viscosity.* All grades of Tolu-Sol have an unusually low naphthene content. *Because of this, Tolu-Sol thinners have very low viscosities for their respective solvency ranges.*

Their lower solvent viscosities can lead to lower finished solution viscosities. Or, at the option of the user, higher solids content with the same finished solution viscosities may be possible.

4. *Odor.* Because they are so highly refined, Tolu-Sol thinners have exceptionally low bulk odor and residual odor.

Wide distribution

Shell's new Tolu-Sol family is *available now* for delivery to all areas east of the Rockies.

> **Memo to West Coast formulators**
>
> New family of Tolu-Sol diluents is not yet available on the West Coast. There, Tolu-Sol W will retain the dependable properties you are accustomed to.

For complete information on Shell Tolu-Sol thinners, see your Shell Industrial Products Representative. Or mail the coupon below.

A BULLETIN FROM SHELL
—where scientists are working to provide better products for industry

—Mail coupon for copy of Technical Bulletin on Tolu-Sol—

Shell Oil Company,
50 West 50th Street,
New York 20, New York

SHELL

Please send me a free copy of your Technical Bulletin No. **SP-61-2** on the new family of Shell Tolu-Sol diluents.

Name ____________________

Title ____________________

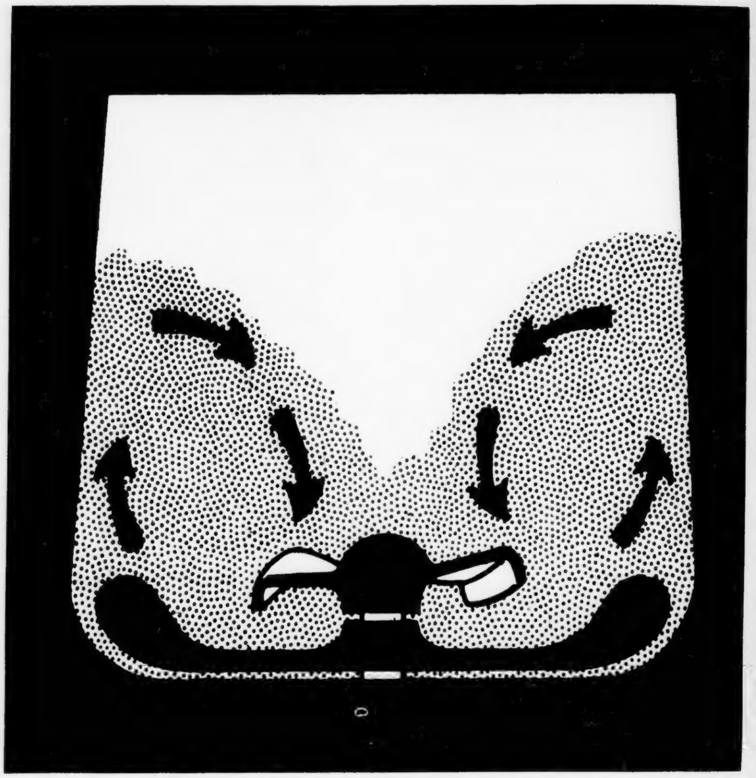
Company ____________________

Street ____________________

City ____________ **Zone** ______ **State** ____________

TWO AGITATORS ON SAME SHAFT STIR THINGS UP

Violent action in mixing zone produces particle-to-particle impingement, reducing wear on equipment and shortening mixing time.



Centrifugal agitator pushes material out, up; impeller thrusts it down.

Last month, this department presented a mixer that used two counter-rotating agitators to exert a high shearing force, with a minimum of circulation, on the material being mixed (*Chem. Eng.*, Nov. 27, p. 74).

Here is another mixer with two agitators, both on the same shaft, that obtains a high shearing force by using a maximum of circulation to promote particle impingement. Various models perform wet and dry blending.

Energy is imparted to the mixture by means of a centrifuging agitator that sweeps the bottom of the vessel and projects the mixture upward and outward. Located above it, a suction agitator or impeller pulls the material downward and thrusts it into the active mixing zone.

The result: aided by a conically contoured vessel, the material develops high shear force by particle-to-particle friction that gives intense mixing with minimum wear on the agitator system.

▶ **Dries While Mixing**—Since the energy from the agitators is transformed into heat, a simultaneous drying of moist materials can readily be achieved. The turbulence pattern inside the vessel leaves a void, permitting the insertion of a vacuum tube to assist drying of the charge.

The unit can be supplied with heating and/or cooling jackets for steam, oil or water circulation. Cooling is particularly important for products that tend to agglomerate when overheated.

For particular applications, the mixer operates under pressure or vacuum. If desired, a thermocouple can be built into the tip of a material-flow baffle (which determines flow pattern inside the unit) for immediate reporting of the temperature of the mix.

Other additions that can simplify operation of the equipment are an illuminated sight port and pneumatically operated lids and discharge ports. Electric drive motors are generally supplied in two-speed design; however, single-speed and variable-speed units are available.

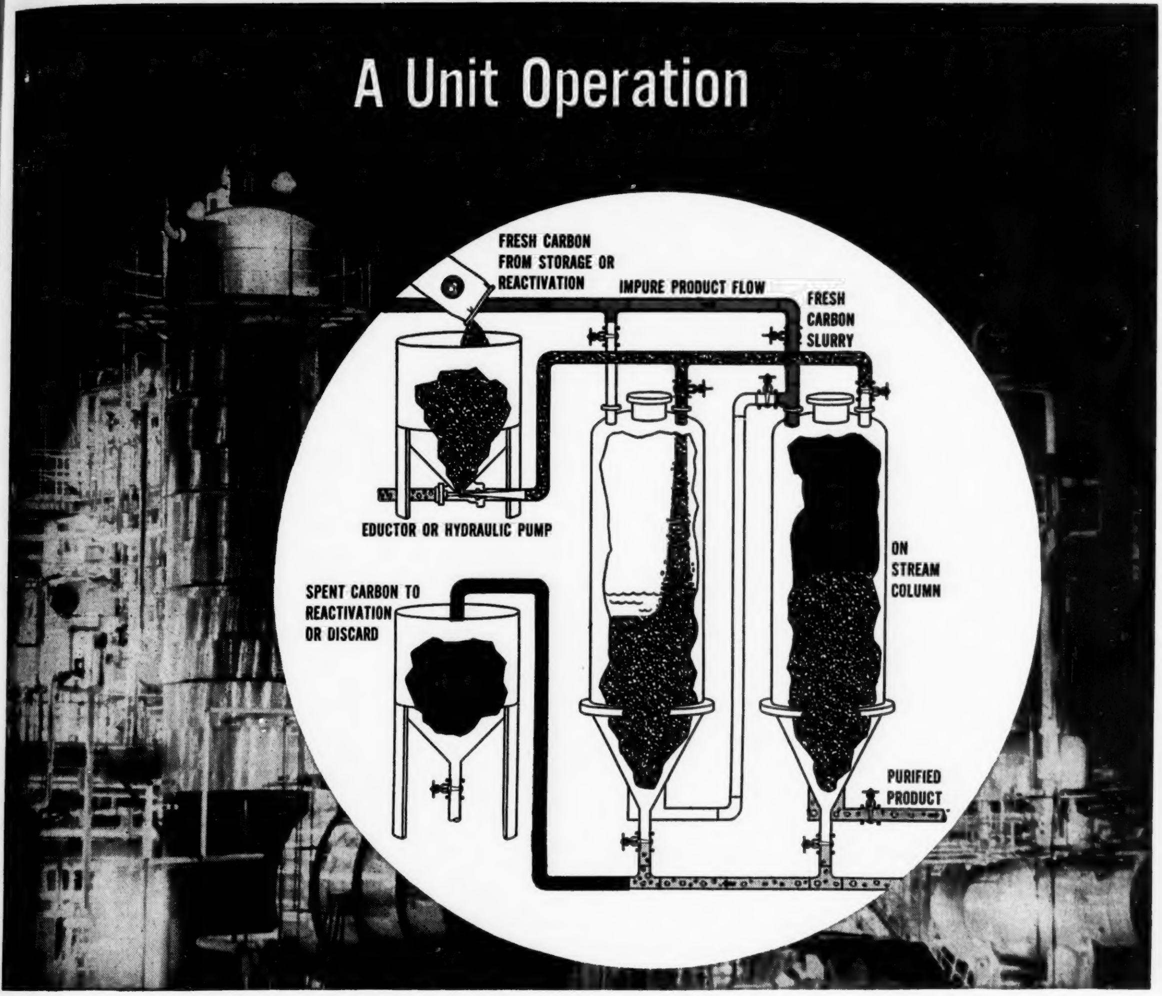
Working capacity ranges from 0.2 to 15 cu. ft. Smaller models are available in all-stainless steel construction, while larger units can be provided in mild or stainless steel.

▶ **Combination Unit**—For special applications such as dry blending of vinyl resin, a combination unit is employed that consists of a two-stage mixing system.

The upper vessel is jacketed for heating and contains pneumatically operated lid and discharge ports. Resin, plasticizer and additives are blended until temperature rises to a preset level, when the mixture is automatically discharged into a second, cooling, mixer via a flexible connection.

The mixture is cooled while being agitated by means of both a cooling jacket and a water-cooled agitator. The cooling cycle is matched to the hot preblend cycle so that when the cool, nonagglomerating product is discharged, another hot charge is ready.

▶ **And Wet Mixing, Too**—Still, another type of mixer is provided for blending of liquids. It develops less energy input than the dry unit, comes in seven sizes with working



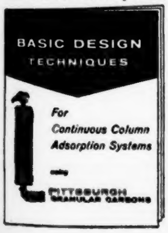
...accomplished more efficiently with Pittsburgh Activated Carbon!

One of the really unique advantages of a continuous column adsorption system, utilizing Pittsburgh Granular Carbons, is that it functions as an engineered unit operation. Pittsburgh Granular Carbon in a column system is one continuous operation that provides maximum adsorption efficiency and can be added to your present production system with relative ease.

Batch-type slurry tanks, filter presses and intermediate handling equipment, with their inherent high cost maintenance, are eliminated.

Pittsburgh Activated Carbon in a column series facilitates a *cleaner* operation, too, with no dust or slurry problems . . . and, more important, you realize greater product yield, utilize less carbon, and, in turn, ***significantly reduce adsorption costs.***

If your adsorption process involves decolorization, purification, deodorization or catalysis, investigate Pittsburgh Granular Activated Carbon. Put these advantages to work in your processing operations to help you produce an even better product . . . at lower cost. 8307



Write For Free Brochure

This brochure illustrates basic design techniques for both liquid and vapor phase, continuous column adsorption systems. Please write for your free copy . . . there's no obligation.

ACTIVATED CARBON DIVISION

PITTSBURGH CHEMICAL CO.

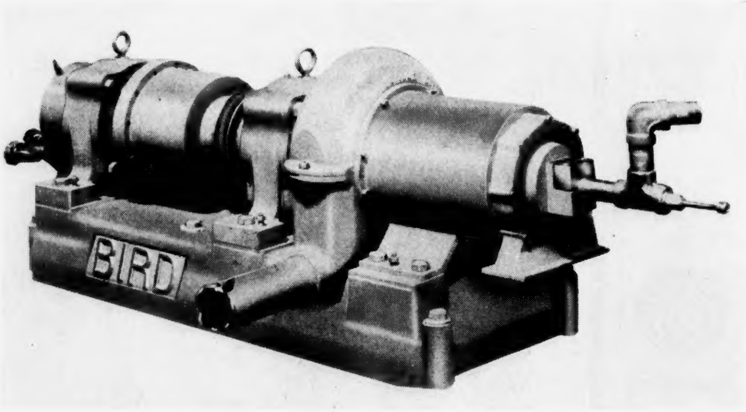
GRANT BUILDING PITTSBURGH 19, PA.

A Subsidiary of PITTSBURGH COKE & CHEMICAL CO.

capacities from 0.3 to 35 cubic feet.

Available in stainless or mild steel, the wet mixer can be supplied with a cooling and heating jacket. Standard jacket can accommodate 45-psi. steam, but jackets for higher temperatures are available for operations that involve cooking. The unit can also be supplied for operation under pressure or partial vacuum.

Called the Papenmeier mixer, the unit in all its forms is imported from West Germany.—**Welding Engineers, Inc., Norristown, Pa.** 48A



LITTLE CENTRIFUGE; BIG OUTPUT

Suitable for pilot-plant or industrial service, this continuous rotating-bowl unit has a large capacity range, the same features as its larger counterparts, and now works under pressure.

Here's a continuous centrifuge for pilot-plant or production service that performs like its larger counterparts, except that it has a bowl diameter of only 6 in., compared with up to 54 in. for the others.

The horizontal unit can handle from 0.1 to 10 gpm. of synthetic resins, food products, pharmaceuticals, mineral slurries requiring classification or dewatering, and a variety of solid-liquid separations. Internal wash of the solids is possible.

And like most of the larger machines, the 6-in. unit can now be operated under pressure up to 70 psi. over its entire speed range. Inert gas used in the seals prevents slurry vapors from escaping during operation.

▶**How It Works**—The device consists of two concentric rotating elements surrounded by a stationary housing. The outer element is a solid-wall bowl, shaped so that solids discharge from a smaller radius than the liquid does; the inner element is a hollow-hub screw conveyor whose blade tips fit closely to the bowl's contour.

Feed slurry, introduced within the conveyor hub, is accelerated to machine speed, then delivered centrifugally through ports into the solid bowl. A gear unit maintains a small constant speed differential between the bowl and conveyor.

Solids settle through the liquid to the bowl wall by centrifugal action, then the screw conveyor moves them continuously toward the small end of the bowl and discharges them as cake.

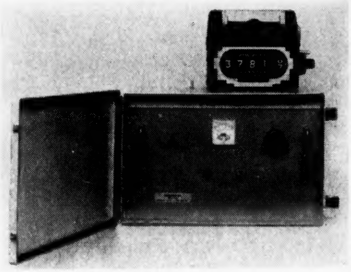
Clarified liquid discharges continuously from the other end of the bowl over adjustable weirs. When desired, wash liquid may be applied through nozzles attached to the conveyor hub; the liquid leaves the bowl with the clarified mother liquor.

▶**Clean Operation**—One of the unit's advantages is that the entire operation is performed completely under cover, and the separation is accomplished entirely by centrifugal sedimentation, requiring that no filter medium be cleaned or replaced.

The device is constructed in a cantilever fashion so that only the portions coming in contact with the products need be handled during cleaning. The drive portion remains undisturbed.

This feature promotes processing of materials where bacterial or other types of contamination require cleaning to the point of complete sterilization; and for research and pilot-plant operations where several different types of materials may be tested each day.

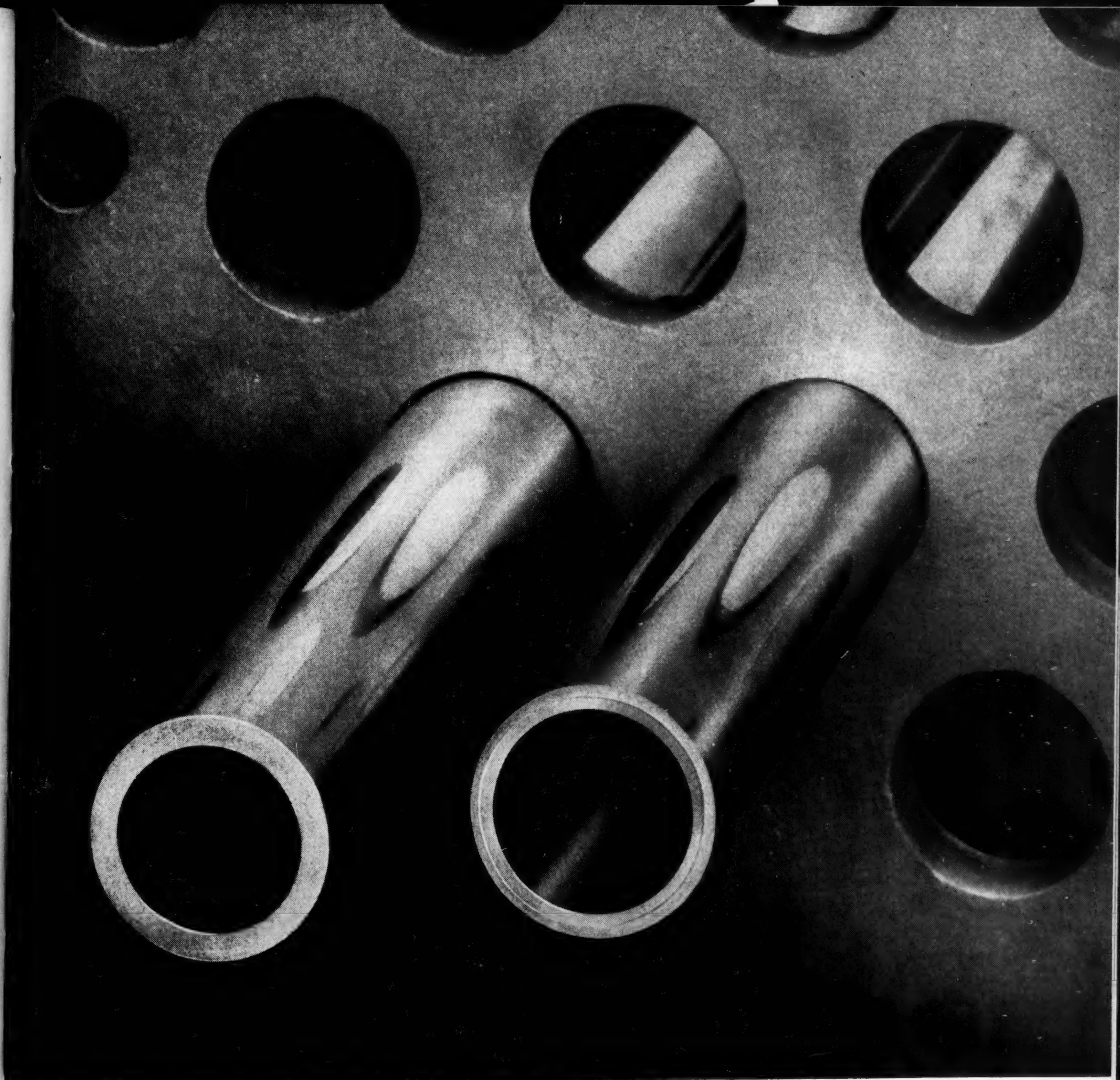
The machine is designed to operate at speeds up to 6,000 rpm. Shear-pin protection is incorporated to guard against damage should feed-rate control become erratic. Type 316 stainless steel is the standard material for the bowl, conveyor, feed pipe and housing, although other materials may be supplied on special order.
—**Bird Machine Co., South Walpole, Mass.** 50A



Flow-volume computer

Unit corrects volume for variations in specific gravity and temperature.

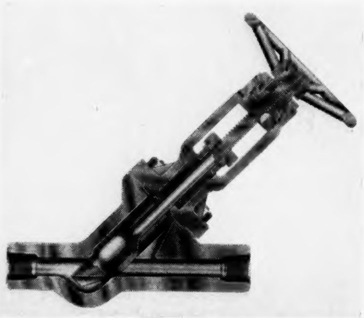
This flow-measurement system for liquefied petroleum gas (LPG) provides continuous readout in barrels, correcting for variations of temperature and specific grav-



ity in the flowing medium. It uses an orifice as the primary flow element and connects to transducers that detect temperature, differential pressure, specific gravity.

Volume reduction or shrinkage is automatically calculated from built-in tables. Said to be more than 99% accurate, the unit has solid-state electronic components for long, unattended service life in the field.

Readout is presented both by visual counter and printed records; telemetered outputs are also available. Compensation for supercompressability is available as an optional feature.—**Computers, Inc., Houston.** **50B**



Hardened control valve

Body, seat and stem tip are made from alloy for abrasion resistance.

For superior abrasion resistance, the body, stem and seat tip of a straight-through control valve are made with a new alloy said to be harder than heat-treated steels.

In addition to high hardness, the alloy has a tensile strength of over 70,000 psi. and greater corrosion resistance than carbon steel.

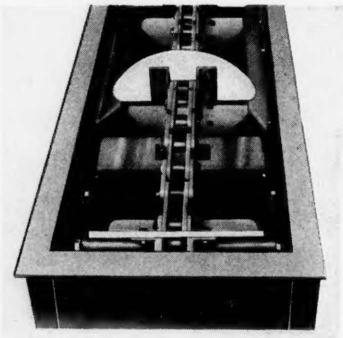
To minimize impingement from the flowing medium, the seat is parallel to the line of flow. A ground face on the seat and tip provides positive shutoff. Test valves containing the new material reportedly outlasted the valves they replaced from two to five times.

Available in standard sizes and pressure ratings, the hardened valve costs about 20% more than a comparable one of carbon steel. —**Flow Systems, Inc., Newport Beach, Calif.** **52A**

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 145)

Repeat performance

Over the period of a year, several new equipment items attract considerably more reader inquiries than the average. Last January, we reprinted the ones that you rated tops. The response was so favorable that a similar review will appear in the Jan. 8, 1962, issue.—FCP



Drag conveyor

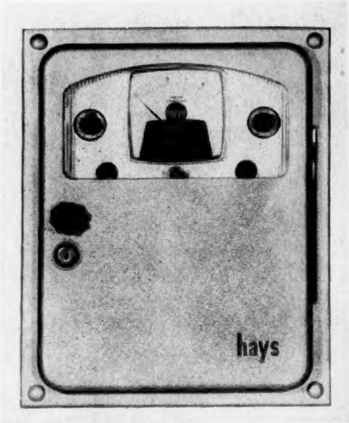
Heavy dependence on plastic parts reduces maintenance, sparking.

A drag conveyor that cleans itself as it operates is designed to handle all types of dry, free-flowing materials. Its flights are made of either polyethylene or heavy-duty neoprene, and the chain-return track is of polyethylene.

This type of construction eliminates metal-to-metal contact except at two points where the chain passes over the sprockets at each end. The result is quiet operation and elimination of sparking in the main part of the system.

The flights are machined to fit the trough exactly, so that there is a minimum carry-over of materials when different ones are handled. In addition, built-in flight guards prevent detracking of the flights and chain.

The device, which comes in widths from 6 to 24 in., is said to require less horsepower than an equivalent screw conveyor.—**Industrial Machinery Co., Inc., Fort Worth, Tex.** **52B**



Combustibles indicator

Analyzer-type unit finds as little as 1% combustibles in gas mixture.

For continuous analysis in solvent-evaporating ovens, jet engine cells, solvent recovery systems and other applications where undesirable or explosive concentrations of vapors may accumulate, this analyzer-indicator detects combustible gases.

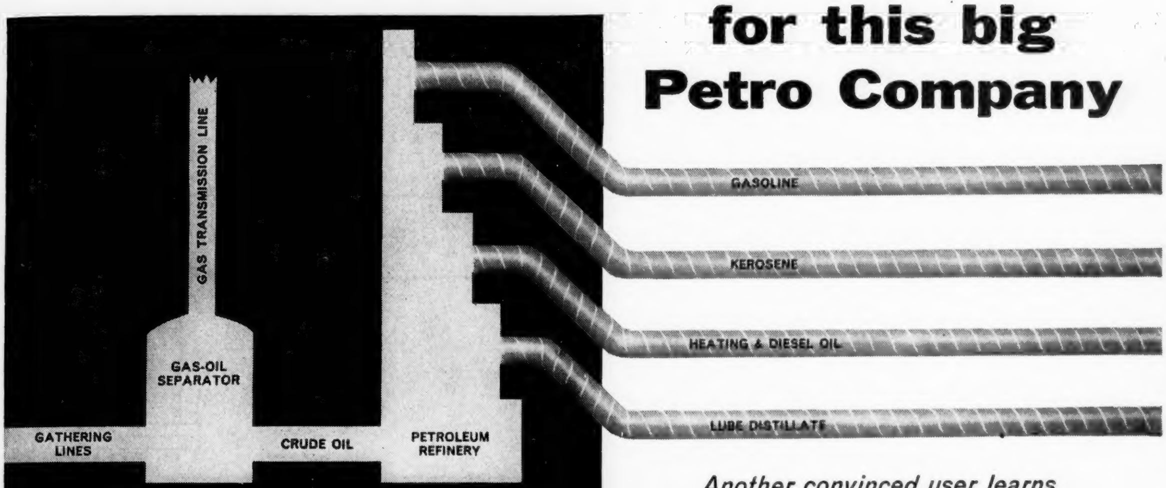
It operates on the principle of catalytic combustion on a heated filament. When a combustible gas passes over the filament, it burns on the surface, increasing filament temperature and electrical resistance. The change in resistance is proportional to the amount of combustible gas present in the mixture.

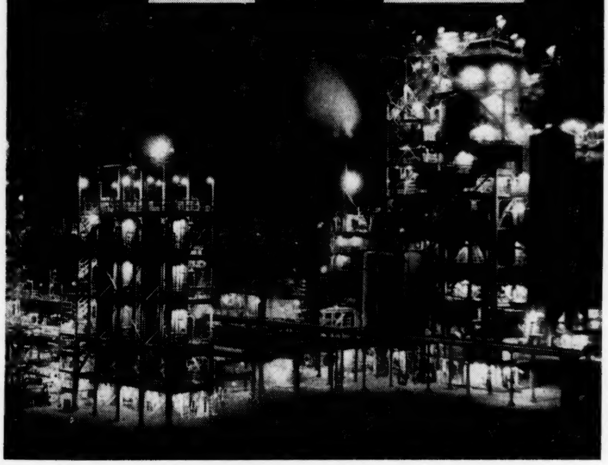
Combustibles in ranges as low as <1% in gas mixtures are measured with an accuracy of ±2% of range, with a response time of

New Equipment continue on page 120

Polyken tape protects products lines

for this big Petro Company





Another convinced user learns the money-saving versatility of one of the world's incredibly tough tapes

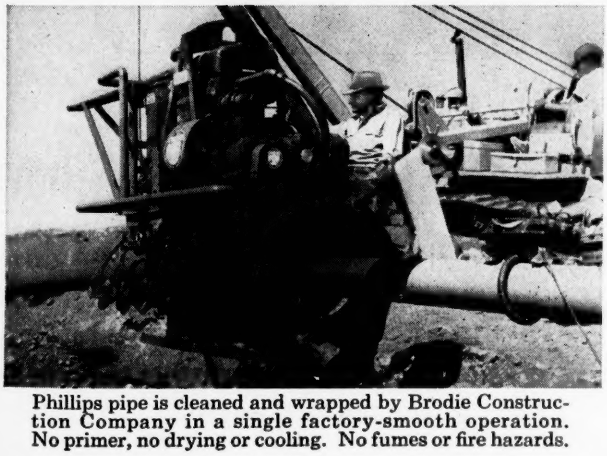
Phillips Petroleum Company chose Polyken No. 960 Extra-Strength Pipeline Tape to protect its products lines. This is why:

- Polyken 960 is a *dependable* pipeline coating. It is easy to handle, simple to apply, resulting in a reliable, quality installation.
- It is *especially* suited to construction of short lines and close work, as on these pipelines carrying crude oil fractions.
- It utilizes high-density polyethylene for maximum durability and corrosion resistance.
- It stands up under tough conditions of terrain and climate—experience-proved in many, many thousands of squares installed throughout the world, in plains, deserts, mountains, swamps.
- Its cathodic protection requirements are low.

AND . . .

- It saves money: Polyken 960 goes on fast with less men per job, covers more miles per day. Less equipment, less handling costs. More savings over the old hot dope idea.

See your Polyken Man . . . call your Polyken Tape Coating Distributor . . . or write Polyken, 309 West Jackson Blvd., Chicago 6, Illinois.



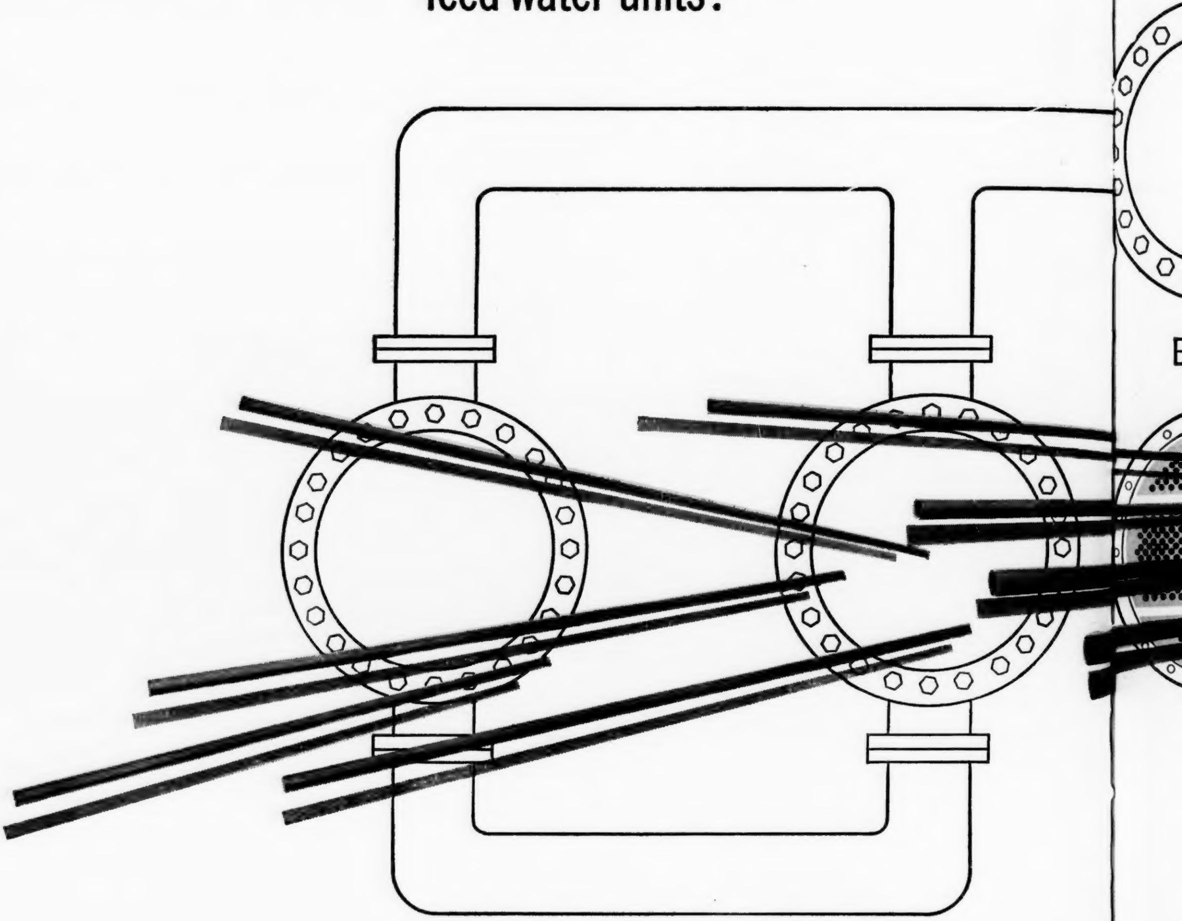
Phillips pipe is cleaned and wrapped by Brodie Construction Company in a single factory-smooth operation. No primer, no drying or cooling. No fumes or fire hazards.

Polyken®

EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division

Need tubes for heat exchangers, condensers, evaporators, coolers, feed-water units?



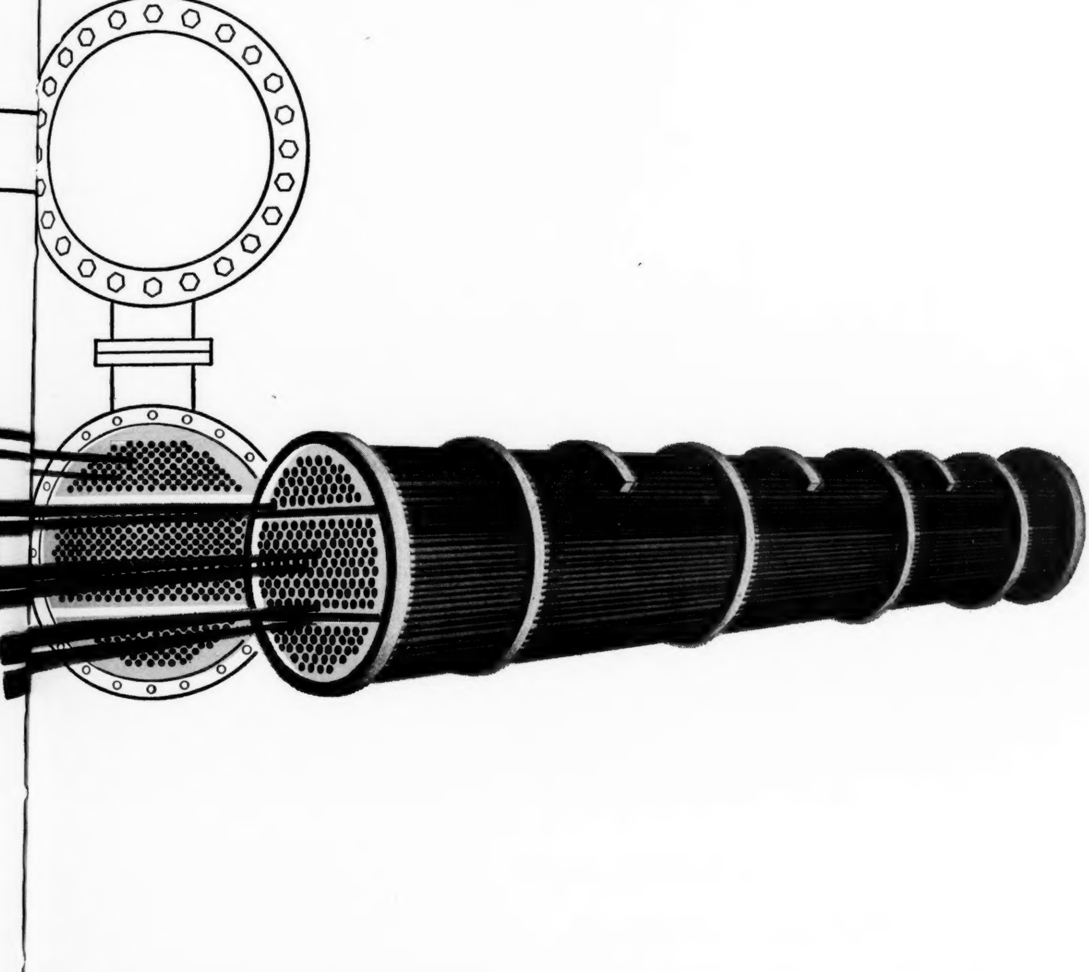
PHELPS DODGE COPPER-BASE ALLOY TUBES have a repu

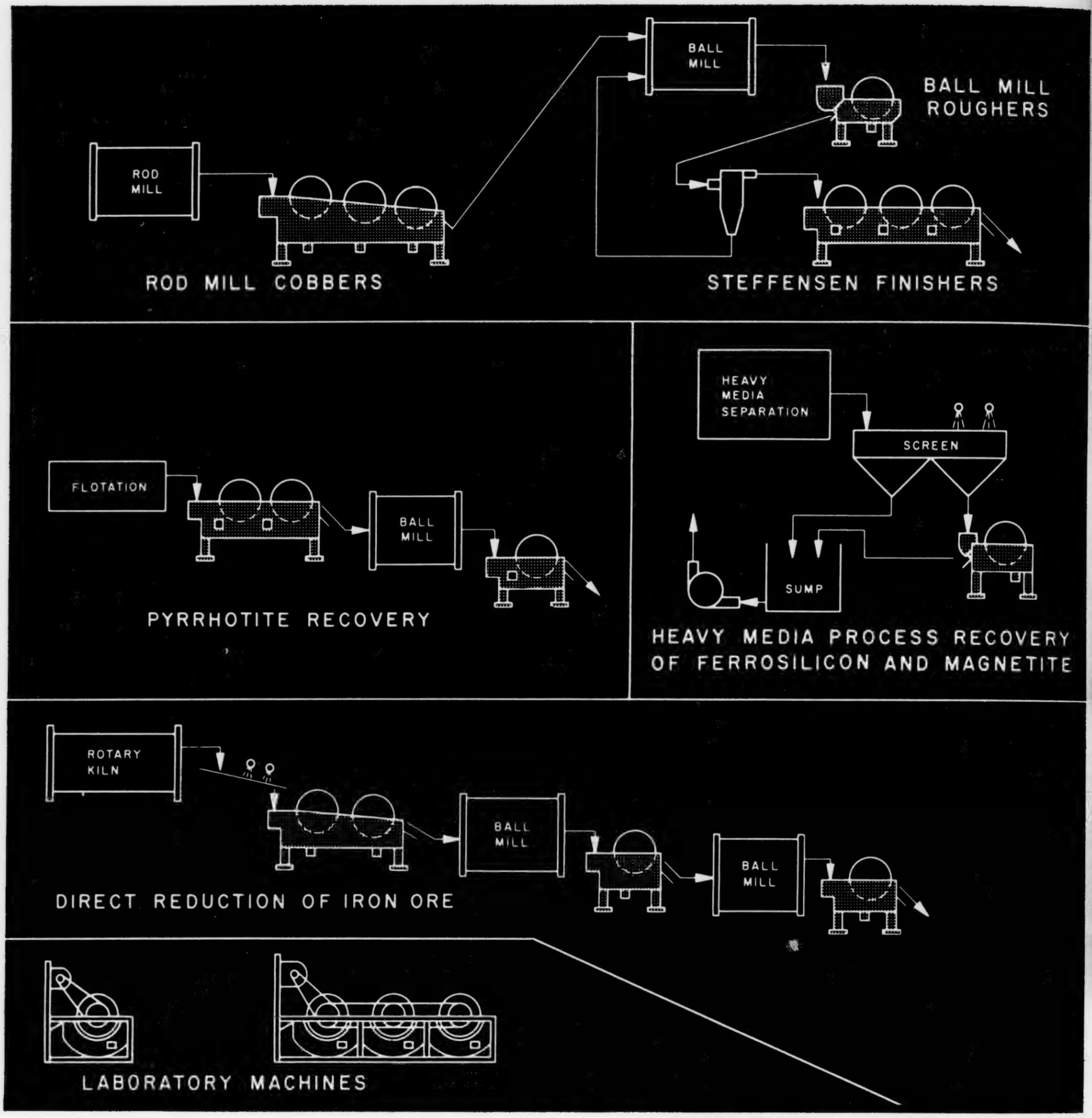
Wide line of finest quality copper-base alloys for every kind of application need—including bi-metal combinations.

National warehouses, completely stocked, in Houston, Beaumont and Corpus Christi, Texas, Baton Rouge and Lake Charles, La., Tulsa, Los Angeles, and South Brunswick, N. J., to serve customers from coast to coast.

Expert
problem
applica

Spec



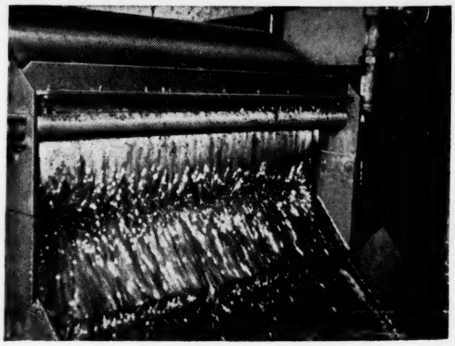


See Jeffrey on your wet concentration and magnetic recovery problems

Jeffrey magnetic separators are exclusively of the drum type. This offers the advantage of extreme simplicity, since the drum is simply a water-tight cylinder of non-magnetic material. It is the only moving part.

Electromagnets, Alnico and the revolutionary new *Ceramic permanent magnets,* located within the drum and extending part way around the interior of the drum, are stationary and are supported on the shaft on which the drum rotates. The angular position of these magnets is adjustable to fit the needs of any particular problem.

Jeffrey engineers will assist you in selecting magnetic separators for your applications. Ask for Catalog 945. The Jeffrey Manufacturing Company, 909 North Fourth Street, Columbus 16, Ohio.



One of twelve permanent magnet machines efficiently recovering magnetite in a large coal cleaning plant.

JEFFREY

If it's conveyed, processed or mined, it's a job for Jeffrey.

An outstanding line of LOUIS ALLIS adjustable-speed drives from 1/2 to 2500 hp.

Louis Allis offers you a complete line of adjustable-speed drives with various characteristics for every application where adjustable speed is required.

Experienced Louis Allis field engineers, supported by regional and factory industry specialists, will help you select the best drive or drive system to meet *your* requirements.

The Louis Allis line of drives provides outstanding control features ranging from simple manual to precise electronic or transistorized control. Selection of control varies, of course, with the nature of the installation and the precision required. Where desirable, speed regulation as close as .1% is obtainable.

Controls can be provided which automatically respond to temperature, pressure, or flow. Other control features include threading, inching, jogging, logarithmic acceleration, torque-limit acceleration, tachometer feedback... and many other control provisions that can exactly tailor a Louis Allis drive to *your* operation.

For process plants or applications involving inter-related motors and multiple drives, Louis Allis engineers can provide complete "systems engineering," furnishing all electrical rotating components and control.

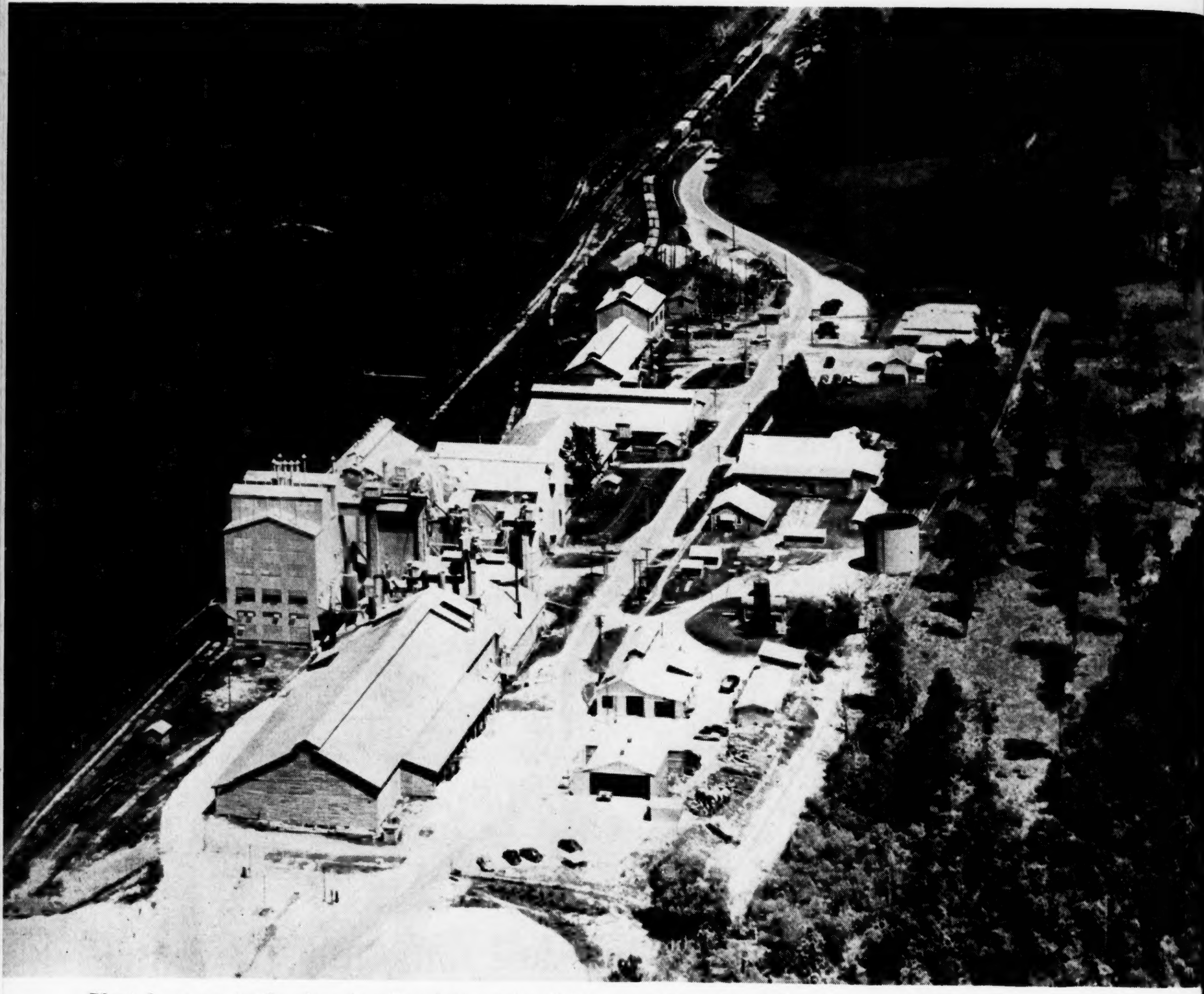
For expert assistance, call your local Louis Allis District Office listed in the Yellow Pages under "Electric Motors"...or write direct to The Louis Allis Company, 447 East Stewart Street, Milwaukee 1, Wisconsin. Ask for Bulletin 2900, "Louis Allis Adjustable Speed Drives."

*TM EATON MFG. CO.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

ASD-238



Plant is conveniently close to attapulgite strip-mining operations that take place in both Florida and Georgia.

Attapulgite: 1 Process, 90+ Grades

This Minerals & Chemicals Philipp Corp. facility in Georgia receives clay from nearby strip-mining, then processes it to satisfy a host of varied end-uses.

N. P. CHOPEY
Assistant Editor

Tucked away in Georgia's southwest corner, a highly flexible plant of Minerals & Chemicals Philipp Corp., Menlo Park, N. J., processes attapulgite into over 90 commercial grades.

Chemically, attapulgite is hydrated magnesium aluminum silicate. It consists of narrow, needleshaped crystals that take on a fiberlike pattern when dispersed in liquids. Among the properties that give the material its usefulness are its chemical inertness, great sorptivity for a variety of fluids, and good capacity to thicken liquids.

Located at Attapulgus, Ga., the plant yields

 Unfold flowsheet

grades with a host of uses: purifying agents for petroleum refining; carriers and diluents for insecticides, herbicides and other agricultural chemicals; additives for drilling-muds; floor absorbents for oils and greases; ingredients for pharmaceuticals and cosmetics; and other applications.

Plant capacity is hard to pin down because it depends greatly on the particular grades being made, but the facility is said to be the largest in the world for processing attapulgite.

▶**Handling Clay**—Although the plant is in Georgia, most of its raw-material clay is strip-mined in nearby Gadsden County in Florida. Since the clay varies in its properties, mine samples are analyzed—the company processes the samples, then actually tries out their suitability for the finished products' various end uses, in bench-scale equipment.

After it has been sampled, trucks bring a given batch from the mines to the plant, where it is stored in a roofed shed. (A 7-10-day feed supply of the raw material is maintained in storage.)

At this point, the clay exists as fairly hard, friable lumps with a waxy surface and olive-grey color. It contains 50% volatile matter, mostly free or combined water.

In the shed, the batches are stored segregated as to their end use. Most of the plant equipment exists in parallel lines, so that more than one grade can be processed at once.

As a first step, conveyor belts transport the clay to hammer mills (equipped with moving breaker plates to minimize clogging) that reduce the material to granules of ½-in. size or smaller.

▶**Extruded, Unextruded**—The plant makes both extruded and unextruded grades, each type having its own specific applications.

To make extruded grades, clay goes from the hammer mill to roll crushers, which yield 1-in. flakes about ¼ in. thick. These enter pug mills and are combined with enough water to make a plastic mass suitable for extrusion.

Pug-mill product is ready for the extrusion step, which breaks down individual bundles of crystals within the clay and thus exposes more of the needles. Company uses three screw-type extruders with multiple-orifice die plates.

Product rods leaving the extruders are 0.4 to 0.75 in. in dia., and the rods are allowed to break up during the handling steps that follow.

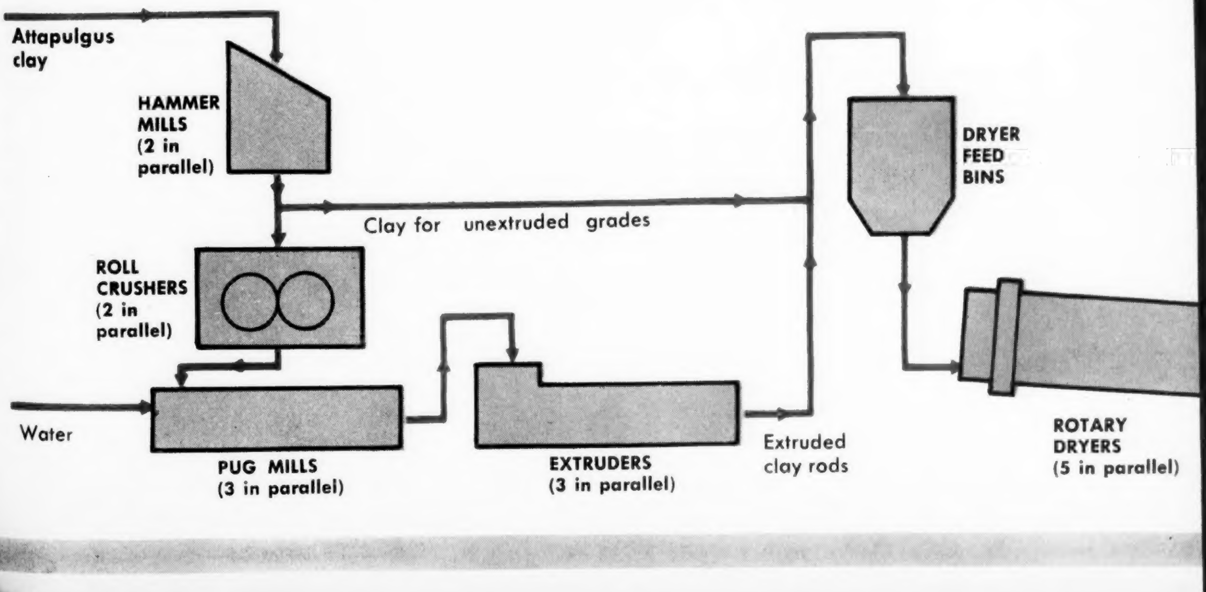
Next step is to dry the material. The plant has five countercurrent rotary dryers: the smallest is 6 ft. in dia. by 60 ft. long, and the largest is 10 ft. by 65 ft. These can be fired by gas or oil, and operate at 300-1,200 F. depending on the grade being produced.

As for unextruded grades, they go directly from the hammer mill to the dryer feed bins, and are dried over the same temperature range.

▶**Fine Grades**—Remainder of the process consists of size reduction and classification. Plant output can be divided into granular products (coarser than 100 mesh) and fine products.

To make fine grades, material from dryer-product storage bins goes to roller-pulverizers. There are five of these, with rolls varying from 40 in. to 60 in. in dia.

For grades of 325 mesh or coarser, output



ded—The plant makes both uded grades, each type hav- applications.

ded grades, clay goes from oll crushers, which yield 1-in. hick. These enter pug mills ith enough water to make a for extrusion.

t is ready for the extrusion down individual bundles of ay and thus exposes more of y uses three screw-type ex- -orifice die plates.

aving the extruders are 0.4 the rods are allowed to break ing steps that follow.

dry the material. The plant nt rotary dryers: the small- 60 ft. long, and the largest These can be fired by gas or 300-1,200 F. depending on uced.

ded grades, they go directly ll to the dryer feed bins, and same temperature range.

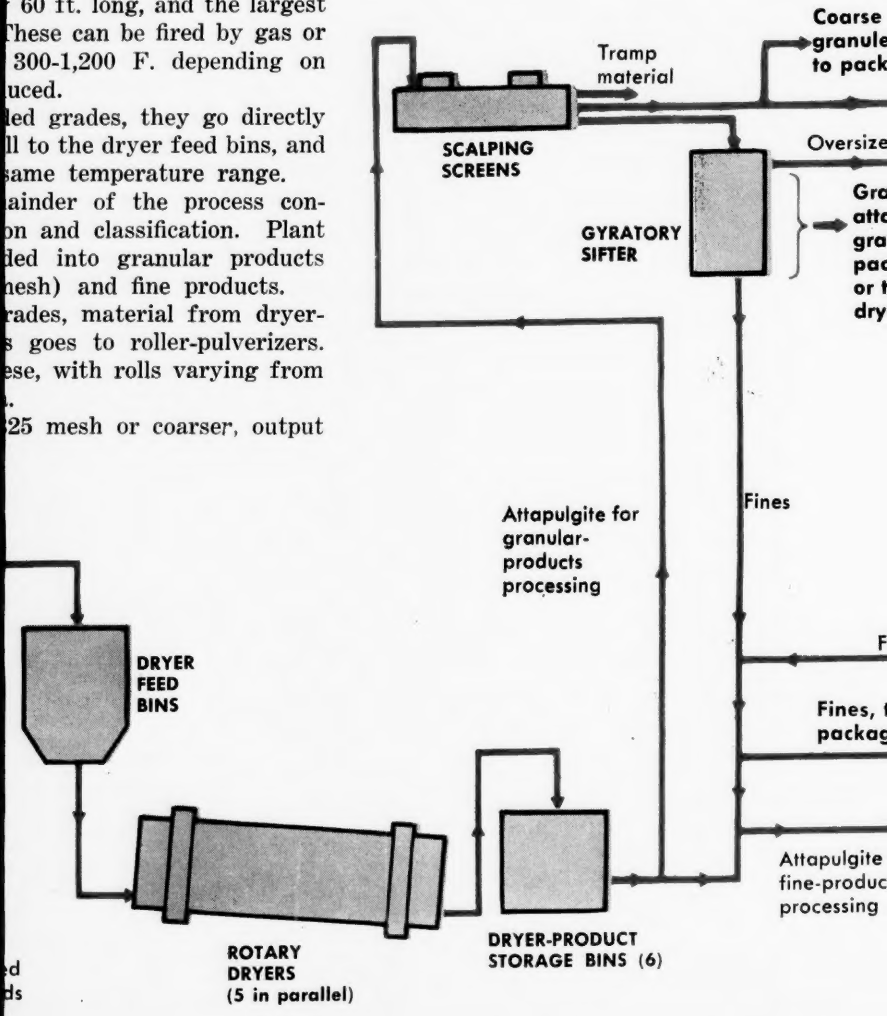
ainder of the process con- on and classification. Plant ded into granular products mesh) and fine products.

rades, material from dryer- s goes to roller-pulverizers. ese, with rolls varying from .

25 mesh or coarser, output is routed directly to product bins. For fi grades, the roller-pulverized material is furt reduced to yield a powder, 60-95% of which finer than 10 microns.

▶ **Granular Grades**—Material for granular sa is routed from the dryer-product bins to a brating, double-deck screen. The top screen moves tramp material. Intermediate product fr the second screen is ground, and fine mate from the bottom of the screen goes directly t sifter for classification.

Oversize from this sifter combines with intermediate cut from the vibrating screen, a the mixture enters a mill bin. From there, passes through a corrugated-roll crusher hav four corrugations per inch.



ns. For finer
rial is further
% of which is

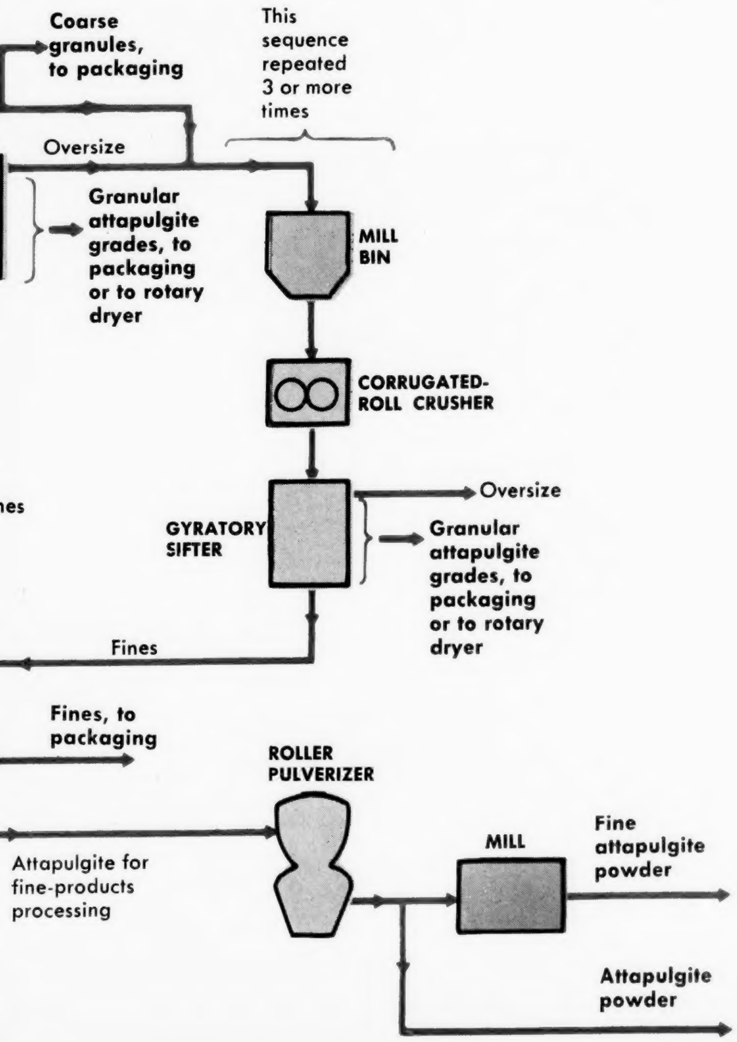
granular sales
bins to a vi-
top screen re-
e product from
fine material
s directly to a

oines with the
g screen, and
'rom there, it
rusher having

Crusher product enters a second gyratory sifter that also separates granular grades. Oversize is sent to further crushing, and the crushing-sifting sequence is repeated several times as required.

Company uses this multiple system for the granular grades in order to keep fines production as low as possible. Whatever fines do emerge from the sifters are either marketed directly or routed to production of powders.

Typical granular grades for marketing are 15/30, 30/60 and 60/90 mesh. In some cases, the granular products are not marketed directly but are sent to the rotary dryers for calcining. Calcined product is cooled by air and is ready for marketing without additional classification.



CHE

MIX-MULLER®

Controlled Dispersion for effective process control

If you mix dry solids, how long has it been since you gave serious thought to the *action* employed by your mixer?

If you're mixing dissimilar and/or disproportionate materials; coating a fine dry material; blending liquids into powder or dispersing a small amount of liquid or binder—you need *more* than a simple stirring, tumbling or agitator action can *give*.

Look at it this way . . . today's raw materials are more uniform, of higher purity and they *cost* more. Quality control standards are stringent. It's easy to get caught in the bind between soaring materials costs, tougher control standards and high *waste*. Oddly enough, processors who spare no expense in otherwise equipping a process with the most modern time-saving components often overlook a principal source of waste . . . *outdated mixing practices.*

We would like to demonstrate
how you can save valuable raw materials and in many cases eliminate secondary processing by making the most of mixing properties—with a Simpson Mix-Muller. Write for details on a confidential, laboratory conducted mulling survey and for our Handbook on Mulling.

P-361R

SIMPSON *MIX-MULLER* DIVISION
NATIONAL ENGINEERING COMPANY
636 Machinery Hall Bldg., Chicago 6, Illinois

Is Radiation Chemistry Practical?

Yes, radiation-induced reactions are practical for certain processes. Here are useful data on reactions, radiation sources, relative costs to help you develop an intelligent answer to this question.

PAUL Y. FENG, *Armour Research Foundation*

It was only during and after World War II that radiation chemistry and other nuclear sciences enjoyed rapid development. This, despite the fact that the history of radiation chemistry goes back to the beginning of the century.

In the past, the chemical effects of ionizing radiation played key roles in nuclear-science development, including the discovery of X rays by Roentgen and of natural radioactivity by Becquerel. By the 1920's, accumulation of knowledge in this field reached a stage that enabled Lind to prepare the radiation-chemistry classic "The Chemical Effects of Alpha Particles and Electrons."

However, the pace of developments greatly accelerated during the 1940's. This was partly due to the wartime need for information on the effects of high-energy radiations on various chemical systems. Also, technological developments in "unrelated" fields such as microwave technology and computer design also spurred experimental and semi-theoretical studies.

Radiation chemistry, which covers the effect of ionizing radiation in matter, differs from photochemistry only in degree—photochemistry usually deals with the non-ionizing events caused by low-energy photons in the visible and near ultraviolet region. Also, radiation chemistry is distinct from radio (or nuclear) chemistry—a subject involving the chemistry (and possibly physics) of various isotopic elements and their compounds. Radiochemistry is not concerned with the effects of radiations emitted by elements or analogous radiations produced by other methods.

Nature of Radiation-Induced Reactions

It is generally agreed that chemical reactions initiated by ionizing radiations are largely caused by secondary electrons. These electrons are produced as a result of the interaction of primary radiations with the irradiated media.

Secondary electrons possess a wide range of energy and, in turn, undergo further interaction processes with environmental molecules. These various interactions produce ionized and excited species (as well as additional secondary electrons). Such species are, generally, extremely reactive, and can initiate a large variety of reactions that occur with different probabilities in the irradiated systems.

Schematically, some of the more important reactions can be written as shown in Table I, p. 68.

In addition to starting materials, all of the intermediate products formed as shown, and other reaction steps, could again undergo similar processes. Thus, a large number of final products (and hence reaction steps) can usually be identified in a given radiation-chemical reaction.

One primary goal of radiation chemists is to determine the relative probabilities and rates of these various processes, and to understand the factors that influence the magnitude of these effects.

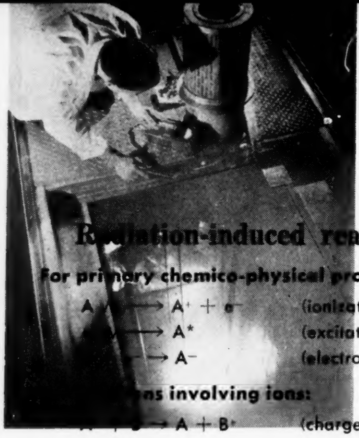
Important Factors That Affect Reactions

There are a number of factors—such as chemical structure, composition, temperature, and the nature of the ionizing radiation used—that usually affect the outcome of a radiation-chemical reaction. These various factors are considered briefly below.

Chemical Structure—The radiation behavior of a compound, as would be expected, depends on its chemical structure.

In general, radiation stability of a specific chemical bond increases with increasing bond strength, whereas radiation behavior of approximately equivalent bonds can often be predicted quite well on a statistical basis. Thus, for example, weakly bonded groups such as iodine are particularly sensitive to radiation.

The conjugated structure of an aromatic compound, however, imparts considerable stability to the nuclear portion of a molecule. Similarly, when such strong chemical effects are absent, as with hydrocarbons, the relative amounts of radiolytically produced methane and hydrogen gas can be readily explained on the basis



Radiation-induced reactions—Table I

For primary chemico-physical processes:

$A \rightarrow A^+ + e^-$	(ionization)
$\rightarrow A^*$	(excitation)
$\rightarrow A^-$	(electron capture)

For reactions involving ions:

$\rightarrow A + B^+$	(charge transfer)
$A^+ \rightarrow B^+ + C$	(dissociation)
$A^+ + e^- \rightarrow A^*$	(charge neutralization)
$A^+ + B^- \rightarrow$ products	(charge neutralization)
$A^+ + B \rightarrow C^+ + D$	(ion-molecule reactions)
$A^- \rightarrow B + C^-$	(dissociation after electron capture)

For reactions involving excited species:

$A^* + B \rightarrow A + B^*$	(energy transfer)
$A^* \rightarrow B\cdot + C\cdot$	(radical formation)
$A^* \rightarrow B + C$	(molecular reaction)
$A^* \rightarrow B$	(rearrangement)

For reactions involving radicals:

$R_1\cdot + R_2\cdot \rightarrow R_1R_2$	(combination)
$R\cdot + DH \rightarrow RH + D\cdot$	(abstraction)
$R\cdot + C \rightarrow RC\cdot$	(addition)
$R_1\cdot + R_2\cdot \rightarrow C + D$	(disproportionation)
$R_1\cdot \rightarrow R_2\cdot + D$	(dissociation)

of the relative numbers of methyl and hydrogen groups in the parent molecule.

Composition—Because of the possibility of various energy- and charge-transfer processes and of reactions of intermediates with environmental molecules, a radiation-chemical reaction is quite sensitive to composition of the irradiated system.

Consider an ordinary thermal reaction. It is conceivable that under certain conditions only one of the reactants will be predominantly activated to form a specific activation complex, regardless of the relative amounts of reactants. However, in a radiation-induced reaction, a change of the relative amounts of components may result in a change in the relative amounts of the various reactive intermediates.

Also, free-radical and ion-molecule processes are very important in radiation-chemical reactions. Thus, sensitivity of these processes toward minute amounts of many chemical species, even the presence of small amounts of foreign materials, may substantially alter the course of a radiation-induced reaction. This is well-illustrated by the radiolytic behavior of water. Pure water is barely decomposed by gamma rays or energetic beta rays if oxygen has been carefully removed from the irradiated system; but water can be decomposed easily if it contains dissolved oxygen.

Temperature—Effects of temperature on conventional and radiation-chemical reactions are inherently different. In conventional chemical processes, thermal energy is responsible for formation of activated intermediates and for their reactions. In radiation-chemical reactions, reactive intermediates are formed by interaction of primary radiations and secondary electrons with irradiated media. Temperature changes would, therefore, not affect the formation of these intermediates, but would influence the rates of reactions of these intermediates with other reactants. Consequently, radiation-chemical reactions can occur at extremely low temperatures, where the outcome often differs substantially from those reactions observed at higher temperatures.

Nature and Intensity of Ionizing Radiation—Reactive intermediates produced in an irradiated system can react with each other as well as with environmental molecules. The outcome of a given radiation-induced reaction will, therefore, be directly dependent on the concentration of these intermediates. And intermediate concentration is directly dependent on the nature and to a lesser extent on the intensity of the ionizing radiation used to initiate the reaction process.

If a heavily ionizing radiation is used (which loses energy rapidly in matter) such as alpha particles, the instantaneous concentration of reactive intermediates along the paths of incoming radiation is necessarily high, favoring their interaction with each other. If low specific ionization radiation is used (which loses energy sparingly in matter) such as gamma rays, reactions of intermediates with environmental molecules will be more probable, since the concentration of these intermediates in the system will be low.

Thus, for example, when pure deoxygenated water is irradiated by heavily ionizing radiations such as fission fragments, alpha particles, deuterons or protons, the hydrogen and hydroxyl radicals tend to react with each other. This leads to formation of molecular hydrogen, hydrogen peroxide and, hence, molecular oxygen. The irradiation of deoxygenated water by sparsely ionizing radiations such as gamma rays or energetic electrons, however, results in very small amounts of decomposition, unless sources of extremely high intensity are used.

Units in Radiation Chemistry

Radiation chemistry involves the conversion of one chemical substance into some other species as a result of absorption of radiation energy. Consequently, radiation-chemical units are necessary to provide quantitative measures of the extent of radiation energy absorbed, as well as the extent of chemical reaction.

The unit for the amount of energy absorbed, or the radiation dose, is the rad. This is defined as the absorption of 100 ergs of radiation energy per gram of irradiated material. A dose of 10^6 rads, or one megarad, is equivalent to about 2.4 cal./g.

Another absolute unit, the electron-volt (ev.)* per gram, is also used in the literature. (Some other units that have been used prior to general acceptance of the absolute units include the roentgen, the roentgen-

*One electron-volt, or the energy required to move an electron over a field gradient of one volt, is equal to 1.6×10^{-12} erg.

equivalent-physical (rep.) and the rather poorly defined pile-unit. Without going into details, 1 roentgen is approximately 0.83 rad, while the conversion factor for the rep. varies with the system irradiated, about 1 rep. = 0.93 rad for aqueous systems.)

Units for the intensity of radiation fields depend on units for radiation dose. Thus, dose rates are expressed in terms of dose per unit time, e.g., rads/hr.

Note that, although the intensity of a radiation field can be a well-defined parameter, the radiation dose received by a sample is usually not the product of radiation intensity and exposure time of the sample. First, radiation intensity is given with reference to a certain material (such as air or water) whose radiation-absorption characteristics might differ significantly from the actual irradiated sample. Also, the presence of excessive heterogeneous interfaces in a radiation field can disturb the secondary electron equilibrium. This effect may be so large that the absorbed dose has little relationship with field intensity.

The unit for yield of a radiation-induced chemical reaction is the G-value. This is defined as the number of molecules, ions or radicals formed or destroyed per 100 ev. of absorbed radiation energy. Since 1 ev./molecule is equivalent to 23 kilocalories/mole, a G-value of 4 is equivalent to an energy requirement of 1,150 kilocalories/mole of product.

Many Radiation Sources

Any ionizing radiation, including cosmic rays and the very high energy particles produced by modern large accelerators, can be used in radiation research. In practice, however, studies in radiation chemistry are usually carried out with isotopic sources or relatively simple but extremely efficient devices such as electron accelerators or X-ray machines.

Isotopic Materials Are Popular

During the earliest stages of radiation research, isotopic sources, such as radium salts or radon, were used extensively to study the effect of radiation on chemical systems. Because of high cost and inconvenience often associated with the use of such sources, they were unable to compete with devices such as X-ray machines in the early years. However, with the recent advent of nuclear reactors, radioactive isotopes have become increasingly available. A growing number of laboratories are equipped with one or more powerful isotopic sources in their research and development centers.

At present, the most important isotope sources are: cobalt-60, which is now produced at low cost in certain power reactors; spent fuel elements from nuclear reactors; and cesium-137 (as well as, to a smaller extent, the beta-emitting strontium-90) obtained as a byproduct in the reprocessing of reactor fuels.

Among the three gamma sources, cesium-137, with a half-life of some 30 yr., has the longest useful life. But cesium-137 emits a radiation that is considerably less energetic than shorter-lived cobalt-60 radiation (half-life = 5 yr.). Fuel elements, on the other hand, decay at a much greater rate. And they also have the added disadvantage that such sources invariably have neutron levels much higher than those of cobalt-60 or cesium-137 of comparable strength.

Consequently, for practical applications, cobalt-60 appears to be somewhat preferable (available in large quantities at a reasonable cost, necessary penetrating power, adequate half-life, and capable of producing a reasonably intense radiation field). It is, therefore, probably for these reasons that more than 20 firms and institutions in the United States have cobalt-60 sources above or at the 10,000 curie level. Megacurie facilities both in Australia and in the U. S. will also be using this isotope as a source of gamma rays.

How Useful Are Machine Sources?

During 1920-1940, machine sources played a significant role in the development of radiation research. Since World War II, machine electron accelerators have become practical and quite reliable radiation sources. They are capable of producing a large amount of radiation energy with relatively low capital investment.

Now, at least three types of electron accelerators have demonstrated their potential values as energy sources for applied radiation technology. These include the Van de Graaff machine, the resonant transformer, and the linear accelerator. In addition, a number of other electrostatic accelerators for the production of mev. electrons are also at various stages of development. All of these machines are capable of providing radiation energy at the kilowatt or greater range—a figure that compares favorably with the 15 kw. output of a cobalt-60 source of exactly 1-million curies.

In addition to electron accelerators, other machines such as cyclotrons have also been used in fundamental radiation chemical research. It is unlikely, however, that these machines would be useful in industrial applications.

Chemonuclear Reactors: Another Way

A chemonuclear reactor is a nuclear reactor designed specifically for chemical applications. As such, it could be either designed to provide heat energy needed for chemical processes (a process heat reactor) or radiation energy.

A large part of the power of such a reactor initially is in the form of kinetic energy of the fission fragments. Thus, a chemonuclear reactor is a low-cost source of megawatt radiation.

Despite such a promise, however, chemonuclear reactors are not without serious difficulties.

The fission fragments are extremely radioactive, and must be efficiently removed by remote control processes from the radiation chemical products. Also, control of a reactor with constantly changing component compositions can be extremely difficult. And, there is a paucity of fundamental knowledge concerning the

radiation chemistry of such very highly ionizing fission energy.

Radiation Dosimetry

From the viewpoint of either fundamental research or practical application, radiation dosimetry constitutes an important phase of any radiation chemical process.

Analysis of the mechanisms of a radiation chemical reaction often requires a precise knowledge of the yield of the various products, and hence accurate information of the radiation energy absorbed by the sample. In practical applications, ability to continuously monitor radiation doses received by processed items would directly affect product quality, as well as cost of the complete process. (It must be emphasized here that radiation energy is an expensive form of energy when compared to either thermal or electric types.)

For laboratory purposes, the universally accepted dosimetry standard is now the ferrous sulfate, or Fricke dosimeter. This is a dilute solution of ferrous sulfate (or ferrous ammonium sulfate) in aerated 0.8N sulfuric acid. Irradiation of this solution results in conversion of ferrous ions into ferric ions as follows:

$$
\begin{aligned}
&H_2O \rightsquigarrow H\bullet + OH\bullet \\
&OH\bullet + Fe^{++} \longrightarrow OH^- + Fe^{+++} \\
&H\bullet + O_2 \longrightarrow HO_2\bullet \\
&HO_2\bullet + Fe^{++} \longrightarrow Fe^{+++} + HO_2^- \xrightarrow{H^+} H_2O_2 \\
&H_2O_2 + 2Fe^{++} \longrightarrow 2Fe^{+++} + 2OH^-
\end{aligned}
$$

Thus, for each molecule of water decomposed, four ferrous ions will be converted to ferric. The $G(Fe^{+++})$ value for this reaction is 15.6. Within limits, this G value is independent of dose rate and temperature. It is, however, limited to relatively low total doses—a considerably lower G value would be effective when dissolved oxygen is exhausted.

In addition to the ferrous sulfate dosimeter, a number of other dosimetry systems also have specific applications. These include, among others, the ceric-sulfate dosimeter (useful for high doses): the cobalt-glass dosimeter (relative convenience); various organic-dye dosimeters; a dosimetry system based on the gelling of polymers (useful as a go-no-go dosimeter); a dosimetry based on the decomposition of polymers (wide range); and various dosimetry systems based on the property changes of organic substances.

All such dosimetry systems, as well as those based on physical principles, have the same difficulty—their radiation absorption characteristics may not be similar to the actual irradiated system. Consequently, a correction factor must be applied to the readings of the dosimeter measurements. These factors are based either on the electron densities of the dosimetry and the experimental systems, or better, on known absorption characteristics.

Consider Some Radiation Chemical Reactions

These various dosimetry schemes are good examples of radiation chemistry at work. Let us consider a few such reactions to illustrate various radiation effects.

Aqueous Systems—The ferrous sulfate dosimetry system is an example of the radiation chemistry of aqueous systems. Other important aqueous systems include: pure water, various solutions, and biological systems.

In general, the radiation chemistry of aqueous systems is characterized by reaction processes by indirect action. Almost invariably, the reaction mechanism involves initial decomposition of water molecules with subsequent interaction of hydrogen and/or hydroxyl radicals with the solute species. These radicals can also interact with each other instead of with the solutes. Mathematical treatment of the diffusion kinetics of aqueous systems has constituted, for several decades, one of the most active areas in the semi-theoretical aspects of radiation chemistry.

Organic Systems—In organic systems various covalent bonds can be broken with relative ease using radiation. The fragments can then react. Furthermore, depending on experimental conditions, radiolysis of organic compounds can proceed via any one or all of the reaction mechanims (radical, molecular, or ion-molecule).

Thus, for example, formation of hydrogen gas during the radiolysis of a liquid hydrocarbon could be either radical or molecular as shown in the following reactions:

Radical reaction:

$$
\begin{aligned}
&C_6H_{14} \rightsquigarrow C_6H_{13}\bullet + H\bullet \\
&H\bullet + C_6H_{14} \longrightarrow C_6H_{13}\bullet + H_2
\end{aligned}
$$

Molecular reaction:

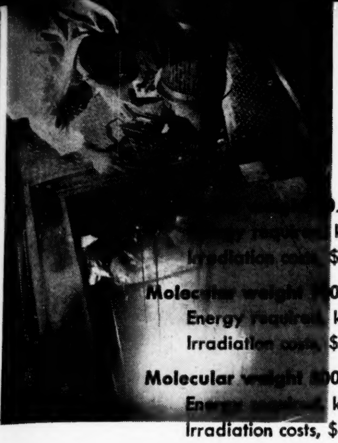
$$C_6H_{14} \rightsquigarrow C_6H_{12} + H_2$$

Both processes probably exist: addition of iodine to hexane will suppress a portion, but only a portion, of the hydrogen yield. Since iodine is considered to be a reasonably efficient radical scavenger, the decrease in $G(H_2)$ in the presence of iodine is often considered to indicate the extent of the radical process. Extent of H_2 formation in the presence of iodine (or other radical scavengers) is taken as an indication of the molecular reaction.

If, instead of liquid hydrocarbon, a gaseous compound such as methane is irradiated, the hydrogen gas may also come from an ion-molecule process as follows:

$$
\begin{aligned}
&CH_4 \rightsquigarrow CH_3^+ + H + e^- \\
&CH_3^+ + CH_4 \longrightarrow C_2H_5^+ + H_2
\end{aligned}
$$

Obviously, other possible reactions, such as those involving the hexyl radical, would also take place.



Energy requirements and irradiation costs—Table II

	G Values†				
	1	5	10	100	10,000
Molecular weight [illegible]					
Energy required, kwh./lb.	24	4.8	2.4	0.24	0.024
Irradiation costs, $*	60	12	6	0.60	0.06
Molecular weight [illegible]0					
Energy required, kwh./lb.	12	2.4	1.2	0.12	0.012
Irradiation costs, $*	30	6	3	0.30	0.03
Molecular weight [illegible]00					
Energy required, kwh./lb.	2.4	0.48	0.24	0.024	0.0024
Irradiation costs, $*	6	1.2	0.60	0.06	0.006
Molecular weight 1,000					
Energy required, kwh./lb.	1.2	0.24	0.12	0.012	0.0012
Irradiation costs, $*	3	0.60	0.30	0.03	0.003
Molecular weight 10,000					
Energy required, kwh./lb.	0.12	0.024	0.012	0.0012	0.00012
Irradiation costs, $*	0.30	0.06	0.03	0.003	0.0003

* Based on $2.50/kwh. † G-Value is defined on p. 69.

These lead to formation of various products having molecular weights both greater, and smaller, than the parent hydrocarbon.

Practical Radiation Chemical Systems

Radiation chemical systems of possible practical interest can be divided into three general groups: food sterilization and pasteurization; radiation processing of simple organic compounds; and radiation processes involving a number of natural or synthetic polymers.

Sterilizing Food

Bactericidal effects of ionizing radiations have been known for many years. But radiation sterilization of food became a practical possibility only during recent years when large radiation sources were developed. Since 1950, a number of countries, including the United States, the United Kingdom, and the Soviet Union, have been studying the radiation sterilization of food. This is a popular topic and has received a considerable amount of publicity.

It now appears that, while radiation sterilization is both feasible and safe, there is still the problem of off-flavor and, to a certain extent, cost. A total dose of some 4 megarads is needed to assure adequate sterilization.

It should be noted that radiation pasteurization does not have these difficulties. And the demonstrated longer shelf-life of many radiation-pasteurized food products attests to the potentialities of this process in commercial ventures.

In addition to food sterilization, high-energy radiation is also used commercially for the sterilization of a number of medical and pharmaceutical products, including yeast, ointments, and medical supplies such as disposable syringes.

Radiation of Simple Organic Compounds

Potentially interesting organic systems must involve either large price differentials or high yields.

This is because of the relatively high cost of radiation energy and usually low G values (~ 3) for many simple organic reactions. Some of the systems which may fulfill such requirements are listed below.

Phenol From Benzene and Water—Here is a system that has received considerable attention because of price differentials and potential volume. Probably, the G value for phenol formation could be increased substantially with increased temperature and oxygen pressure.

Hydrazine From Ammonia—In an analogy to the phenol system, preparation of hydrazine from ammonia, if successful, would also constitute a particularly favorable process. At present, this process still appears to be feasible, on the basis of electric-discharge experiments.

Ethylene Glycol From Methanol—Both the price differential (factor of about 3) and the potential volume (possibly exceeding 1-billion lb./yr. in a few years) makes this synthesis an attractive process. At present, the G value for the conversion reaction is in the order of 2-3.

Preparation of Fluorinated Compounds—Organic fluorine compounds often have unique chemical and physiological properties, but are usually somewhat difficult to synthesize. Radiation chemical methods permit introduction of fluorine or fluorine-containing groups to complicated molecules under mild and controlled conditions and are of potential interest. The G value for some of the reactions studied are of the order of 2.

Preparation of Alkane Sulfonyl Chlorides—Many hydrocarbons, when irradiated in the presence of sulfur dioxide and chlorine, could incorporate the SO_2Cl group in very high yields. In addition, the disulfo-

chlorinated product, which may be useful as intermediates for the preparation of polymers, is also formed in good yield.

Radiation Processing of Polymers

Use of ionizing radiation to process polymers or polymerizable materials still constitutes one of the most promising areas of applied radiation. This is due to the very high molecular weights involved and the possibilities for chain reactions.

Cross-Linking of Polymers—Among the better known processes are: preparation of heat resistant polyethylene for various domestic and industrial applications; the *L*-film of W. R. Grace & Co.; and treatment of silicone products.

Graft-Copolymerization Reactions—Some of the examples in this area include the ion-exchange membranes produced by American Machine and Foundry and the Raibond of Radiation Applications. At present, application of the radiation-induced graft copolymerization process to the treatment of textiles seems to have considerable promise. A number of laboratories, both in the U. S. and abroad, are engaged in research and development work in this area.

Polymerization of Monomers—Radiation processes could, in principle, be used to prepare many polymeric substances from the corresponding monomers. But such processes must compete both in economy and in product quality with other highly developed methods in the polymer industry. Consequently, with the exception of some limited Japanese efforts in low-temperature polymerization reactions, there is not enough incentive for industrial organizations to prepare commercial products by irradiating monomeric material directly. Nevertheless, much work in this area is still going on in many laboratories, with current emphasis on polymerization at low temperatures. Results of such studies usually indicate that the reactions have a pronounced ionic character, and that the polymers obtained often have higher degrees of crystallinity than those obtained at higher temperatures.

Economics of Applied Radiation Chemistry

As an illustration, the cost of radiation energy in kwh. units will be calculated using the following assumptions for a 1-million curie cobalt-60 source: (1) initial cost of the facility is $1 million, (2) the expected return on investment is 6%, and (3) the operating cost, depreciation, and source decay amount to 20% during the first year.

Average energy output of the source during the first year is 14.1 kw. (being 14.8 kw. initially), the average cost of radiation energy is then $2.1/kwh. Assuming further that 80% of this energy can be used productively, the cost becomes finally $2.5/kwh. of absorbed radiation energy.

Irradiation Costs of Selected Processes

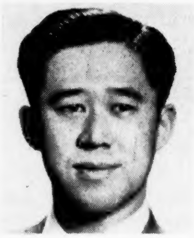
Food Sterilization and Pasteurization—Assume that 4.5×10^6 rads will be needed for food sterilization and 2.0×10^5 rads for pasteurization. Energy required per pound of food will amount to 5.6 watt-hr. for sterilization and 0.26 watt-hr. for pasteurization. At $2.5/kwh., the irradiation costs per pound of food are then 1.4¢ and 0.065¢ respectively.

Chemical Synthesis—Assume that a compound (molecular weight = 100) can be synthesized with $G = 5$, the total energy required per pound of product is then $(100/5) \times 1.6 \times 10^{-12} \times 6.02 \times 10^{23} \times (450/100) = 8.69 \times 10^{11}$ ergs or 2.4 kwh. At $2.5/kwh., the irradiation cost is then $6/lb. Similar calculations for other molecular weights and *G*-values have also been made. These are given in Table II on p. 71.

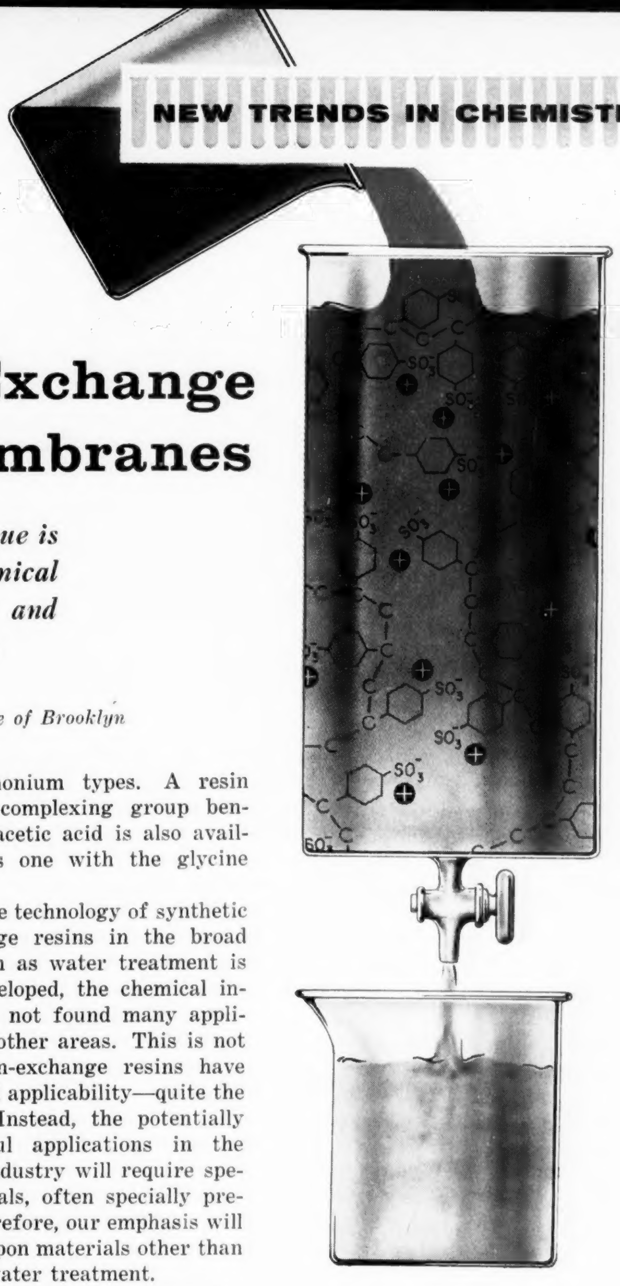
References

1. Swallow, A. J., "Radiation Chemistry of Organic Compounds," Pergamon, 1960.
2. Haissinsky, M., (Ed.), "The Chemical and Biological Action of Radiations," Academic Press, 1960-1.
3. "Proceedings of the First International Congress of Radiation Research" (Radiation Research, Supplement No. 1), Academic Press, 1959.
4. "Proceedings of the First International Conference on Peaceful Uses of Atomic Energy," Vol. 7, United Nations, 1956.
5. "Large Radiation Sources in Industry," Vol. 1, 2, International Atomic Energy Agency, Vienna, Austria, 1960.
6. *Nucleonics,* special issue on radiation chemistry, Vol. 19, No. 10 (1961).
7. *Scientific American,* special issue on radiation chemistry, Sept. 1959.
8. *Jour. of Chem. Education,* special issues on radiation chemistry, Vol. 36, No. 6, 7 (1960).
9. "Proceedings of the Second International Conference on Peaceful Uses of Atomic Energy," Vol. 29, United Nations, 1958.
10. *Annual Review of Physical Chemistry* and *Annual Review of Nuclear Science,* Annual Reviews, Inc., Palo Alto, Calif.

Meet the Author



PAUL Y. FENG, *is supervisor of chemical physics research at the Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. He received his B.S. in 1947 from the Catholic Univ. in Peiping, China. Coming to the U. S. in 1950, he studied at Washington University of St. Louis, and received his Ph.D. in 1954. Dr. Feng was connected with the American Testing Laboratories, in 1954-55, then joined ARF. His experience is in the fields of nuclear and radiation chemistry. He served on various occasions as lecturer on nuclear chemistry, radiation chemistry, and nuclear physics at the graduate school of I.I.T., as a visiting professor at the Institute of Nuclear Science in Formosa, as a technical advisor on the U.S. delegation to the 2nd International Conference on the Peaceful Uses of Atomic Energy at Geneva in 1958, and a member of the U.S. delegation to the International Atomic Energy Agency Tritium Symposium in Vienna in 1961. He has published a number of papers, is a member of ACS, Amer. Phys. Soc., Amer. Nucl. Soc., Radiation Res. Soc., and Sigma Xi.*



Using Ion-Exchange Resins and Membranes

This separation technique is finding favor in chemical processing. Its theory and practice are examined.

HARRY P. GREGOR, *Polytechnic Institute of Brooklyn*

Ion-exchange resins are simply insoluble organic matrices to which are attached specific groupings either of ionic character or that are capable of ionic reactions. This base matrix material can be cross-linked polystyrene, a natural product such as cellulose or, where more stable materials are desired, a fluorinated polymer. The figure at right shows diagrammatically a typical water-treatment resin—in this case, sulfonated polystyrene.

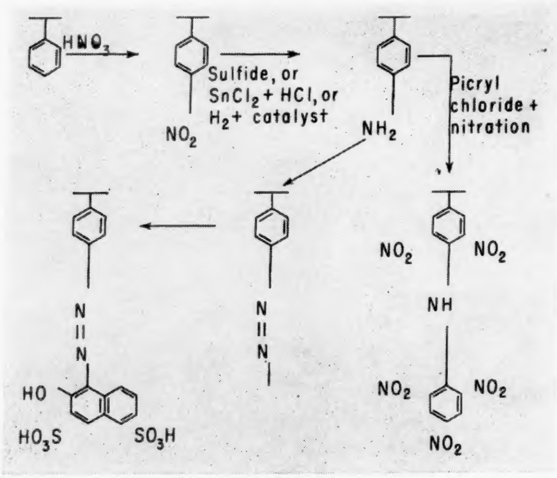
In general, ion-exchange polymers are prepared either by forming a insoluble resin and then treating it chemically to attach the desired grouping, or by polymerizing or copolymerizing a mixture of monomers, one of which contains the desired group. From an economic point of view, it is usually more practical to employ the former procedure, as is the case illustrated at right where cross-linked polystyrene beads are sulfonated directly.

The technology of ion-exchange resins of the water-treatment type is well-established. Almost all the commercial resins are based upon cross-linked polystyrene, with cation-exchange materials of the sulfonic acid, phosphoric acid and carboxylic acid types, and with anion-exchange materials of the weak-base polyamine and quaternary ammonium types. A resin with the complexing group benzyliminodiacetic acid is also available, as is one with the glycine group.

While the technology of synthetic ion-exchange resins in the broad field known as water treatment is highly developed, the chemical industry has not found many applications in other areas. This is not because ion-exchange resins have this limited applicability—quite the contrary. Instead, the potentially most useful applications in the chemical industry will require special materials, often specially prepared. Therefore, our emphasis will be placed upon materials other than those for water treatment.

Several years ago, the Norwegian chemist Skogseid[1] showed that one could carry out many classical chemical reactions on an insoluble matrix. Skogseid treated polystyrene with nitric acid to produce polynitrostyrene, reduced this group to the anilinium analogue and then treated it with picryl chloride to produce a polymeric form of dipicrylamine (see Fig. 1). Dipicrylamine is the familiar potassium-specific reagent in analytical chemistry and, in resin form, it absorbs potassium selectively over sodium by a ratio of about 10:1. Skogseid also prepared a diazonium salt of polystyrene and from this a wide variety of compounds, one of which is also shown in Fig. 1. The work of Skogseid has led to the preparation of a number of resins having a specific affinity for certain metallic ions.[2] Complexing resins can also be prepared by polycondensation reactions.[3] Thus, it would appear that an insoluble resin having almost any desired group either on its surface or fixed to its inner pore or gel structure can be prepared.

These new resin types will be discussed on the following pages.



Two resins based on polystyrene—Fig. 1

New Resins

In listing some of the interesting materials that have been prepared, mention should be made of the work of Miles[4] who treated a phenol-formaldehyde polymer with mercuric acetate to form the phenyl-Hg^+ fixed group, one which is specific for the absorption of mercaptans. Work on the preparation of organo-metallic polymers is continuing, particularly by Russian investigators.

Esters formed by the reaction of polymeric alcohols and hydrated metallic oxides were known for many years. This reaction was employed recently to produce molybdate resins that were able to absorb a number of sugars, amino acids and polyols selectively from concentrated salt solutions.[5]

A new and particularly interesting application has been the preparation of resins containing optically active groups that are capable of resolving racemic mixtures. While many attempts in this direction have been reported, some of the recent work by Rabek apparently shows considerable promise.

Another, most interesting resin is reported by Manecke who, starting with polystyrene containing either diazonium salt or isocyanate groupings, was able to couple proteins, enzymes and other, similar materials to the polymer without substantial loss of biochemical activity. Resins with attached antigens were capable of antigen-antibody reactions, and resins with appended enzymes showed considerable enzymatic activity. The applicability of these materials to the pharmaceutical and fermentation industries is certainly obvious.

Many resins containing groups capable of oxidation-reduction reactions have been prepared. Cassidy has pioneered in this field with his vinylhydroquinone polymers, and further work by Manecke[6] and by Gregor and Beltzer[7] has led to materials of the same type, which are prepared by polycondensation reactions. For example, the reaction between pyrogallol and formaldehyde can result in a stable and highly porous exchange material, one of considerable interest because of the strong reducing power of pyrogallol and the low cost of the resin. These insoluble redox resins can be reversibly oxidized and reduced through many cycles with apparently little loss in capacity as long as the oxidation is not too vigorous. In their reduced state, the resins can reduce iodine, oxygen to peroxide and hydroxide, and most metals from their higher to lower valent states, readily and with good capacity. Similarly, in their quinoid state, these resins act as mild oxidizing agents. In columns, they act as the organic analog of the Jones reductor but without the introduction of foreign material into the reaction mixture.

Conductive Redox Polymers

A new development is the preparation of redox polymers that also possess electronic conduction. Weiss, in Australia, has reported the preparation of oxidation-reduction polymers that apparently possess eka-conjugation in their matrix structures. The ordinary redox polymers can also be made electronically-conducting by the incorporation of charcoal or graphite particles in their structure or by a physical admixture.[8] The recent work of Arnold and Murphy[9] apparently follows along similar lines.

Stable oxidation-reduction polymers with electronic conduction would make feasible the electrical regeneration of ion-exchange beds. For example, a pyrogallol resin in the reduced $R(OH)_2$ state could react with an alkaline sodium ion solution to form

$$R(OH)_2 + 2\,Na^+ = RO_2^{--} \cdot 2\,Na^+ + 2H^+$$

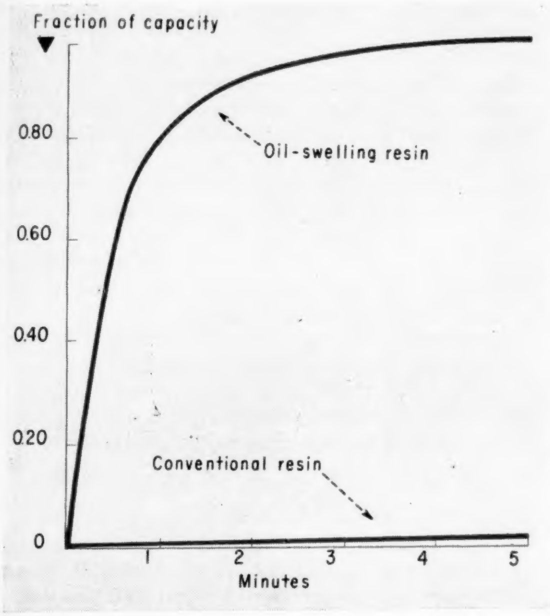
Making the exchanger the anode of a cell would result in

$$RO_2^{--} \cdot 2\,Na^+ - 2 \text{ electrons} = RO_2 + 2\,Na^+$$

with the sodium ion migrating out of the resin, and reduction taking place at an external cathode. The resin is regenerated finally by reduction as the cathode. Cation exchange based upon very weakly acidic materials such as hydroquinone or pyrogallol is probably not too practical in neutral media; stable redox resins of stronger acidic character are yet to be prepared. Similarly, redox resins capable of anion exchange can be prepared but practical advances in this direction have not been reported. The availability of both these materials would make possible electrically regenerable deionization devices. It appears that the principal advantages to the use of electrically regenerable oxidation-reduction resin units would be in their convenience. For large units, the use of ordinary resins and chemical regeneration will probably be considerably more practical.

Oil-Swelling Resins

Another new and most interesting advance has been in the development of ion-exchange polymers capable of use in completely nonaqueous media, the so-called



Absorption of diethylamine from hexane, using an oil-swelling resin—Fig. 2

oil-swelling resins. With the conventional water-treatment resins, the rate-determining step of exchange reactions is almost invariably that of diffusion into and out of resin particles. It is only in water and other highly polar solvents that ordinary resins, being strongly hydrophilic, swell sufficiently to allow ions or molecules to diffuse at practical rates.[10]

The degree of cross-linking of these resins has little effect upon their permeability in nonaqueous solvents. This does not mean that water-immiscible solvents saturated with water or water-in-oil emulsions cannot be treated by water-wetted ion-exchange resins. Indeed, under these circumstances, exchange proceeds almost normally, with the rate-determining stop often being transport of material across the oil-water interface. It was shown[8] that the demineralization of seawater in petroleum-oil emulsions could be carried out satisfactorily, particularly when a demulsifying agent was added.

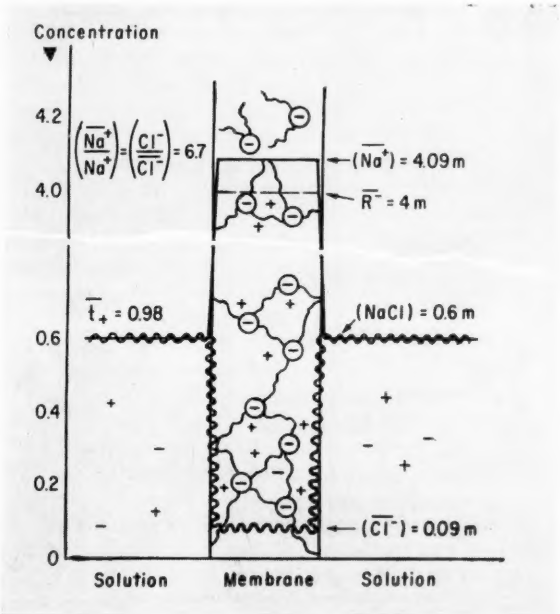
The preparation of oil-swelling ion-exchange resins of strong acid, weak acid, strong base and weak base character that function efficiently even in solvents such as benzene or hexane has been achieved.[8] Fig 2 shows the rates of absorption of diethylamine from hexane by the conventional sulfonic acid resin Dowex 50 and an oil-swelling sulfonic-acid polymer. It appears that all of the classical ion-exchange reactions can occur in almost any solvent system with oil-swelling resins. For example, an oil-swelling sulfonic resin was used to treat the nonionic ferric acetylacetonate complex dissolved in hexane, and a rapid rate of exchange of the hydrogen for the ferric ion with good resin capacity was obtained.[8]

Many applications of resins suitable for use in nonaqueous media are evident. In the petroleum industry, they could be used to remove dissolved metallic impurities as well as a number of other materials too soluble in oil to be partitioned into an aqueous phase. These resins could be used for the uptake of fatty acids from edible oils, to solve a host of recovery and purification problems in nonaqueous solvent systems, and as acid or base catalysts.

Inorganic Exchangers

The original ion-exchange materials were inorganic; for many years, the natural zeolites were the only ones available. Inorganic exchangers have certain inherent advantages over organic polymers. They can be used at high temperatures (> 300 C.) while the conventional ion-exchange polymers, even under best conditions, are not ordinarily stable at temperatures higher than 150 C. Also, inorganic exchangers are essentially capable of showing a high degree of specificity in that they can exchange with one ion but not with other, similar, ions; in being crystalline, they can possess pores of extremely precise and uniform diameter. For example, the common feldspar mineral, orthoclase, shows a distribution coefficient for rubidium or potassium over sodium that is greater than 30:1; with organic exchangers, this value is not higher than 3:1.[11] Other very sharp separations between highly similar materials by synthetic inorganic zeolites are

Membrane system for desalination—Fig. 3



known; the work of Barrar and the commercial development of molecular sieves may be cited.

Synthetic exchangers based upon the oxides, tungstates, molybdates and phosphates of zirconium have been known for some time; further advances in these directions have been reported by Kraus,[12] and the Minnesota Mining and Manufacturing Co. has prepared inorganic exchangers in bead form. Work on new inorganic exchangers based upon inorganic polymers is under way. Andrianoff has reported the preparation of ion-exchange materials based upon some of his inorganic polymers, but definitive information is lacking. Developments in the next few years will probably produce inorganic exchange materials of real interest, possibly ones that are strongly acidic or basic, in contrast to the weak-acid and weak-base inorganic exchangers currently available.

It has been emphasized that many of the purely chemical (as distinguished from water-treatment) applications of ion-exchange materials call for resins not now available commercially. The technology involved in the preparation of new resins for specific applications is well-established and not particularly difficult. It is anticipated that we shall see the extensive development of specific resins for specific chemical applications.

Membranes

Ion-exchange membranes are essentially ion-exchange resins in the form of thin sheets. It has not been possible to make large sheets of highly cross-linked polymers because these are too rigid. Instead, membranes are made by either of two methods.

In the first method, ion-exchange resin beads are suspended in an inert plastic matrix, with the resin-to-matrix polymer ratio such that most of the beads are in contact with one another. The preparation of these membranes is fairly straight forward and has been described in some detail by Beiber.[13]

These heterogeneous membranes can be prepared directly from any granular resin, and many choices of matrix polymers are available. However, the membranes possess certain disadvantages since it is not possible to bond the hydrophilic resin particles to the hydrophobic matrix. Comparatively wide pathways across the membrane remain at these junctures; herein, precipitation can take place, colloidal matter can migrate and (as will be discussed later) the pathways allow a high electro-osmotic rate of water transport. Also, because of their heterogeneous nature, these films are intrinsically weak and must be fairly thick—increasing material costs.

Homogeneous ion-exchange membranes appear to be a single substance under the microscope. They are intimate molecular blends of largely linear film-forming polymers for matrix structure, and electrolytes for exchange groups; cage polymers or interpolymer mixtures are common.

Basic Principles

A number of laboratories are investigating the preparation of ion-exchange membranes; Table I lists current commercial suppliers of ion-exchange membranes of homogeneous and heterogeneous character. Some of these also make equipment; still others make equipment only.

One should think of a membrane as a concentrated solution of an electrolyte, where one of the ionic species is fixed to a matrix and the other (opposite in charge) is mobile. Within the membrane phase, the concentration of fixed and mobile ions is quite high, of the order of 4 to 8 molal* (moles per 1,000 g. of sorbed water). The thermodynamic concentration in a membrane should refer to sorbed water or molality rather than molarity or bulk concentration, because the latter term includes the inert matrix. Fig. 3 shows diagramatically a membrane system of the fixed anion, mobile cation type (a cation-exchange or cation-permeable membrane) such as a sulfonated polystyrene membrane in the sodium state in equilibrium with 0.6 *m* sodium chloride (approximately the concentration

* The abbreviation "*m*" will be used for molal, "*M*" for molar.

Membrane Manufacturers—Table I

United States

- American Machine and Foundry Co.
- Ionics, Inc.
- Nalco Chemical Co.
- The Permutit Co.*

Foreign

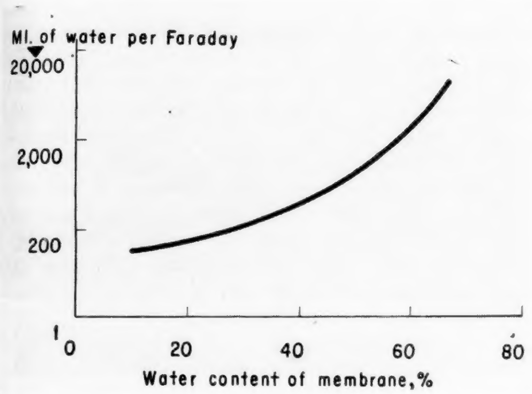
- Asahi Chemical Industries
- Asahi Glass Co.
- British Water Softeners (Permutit Ltd.)*
- Imperial Chemical Industries
- T. N. O., Holland
- Toyo Soda Co.*

* These manufacturers make heterogeneous membranes; the others, homogeneous

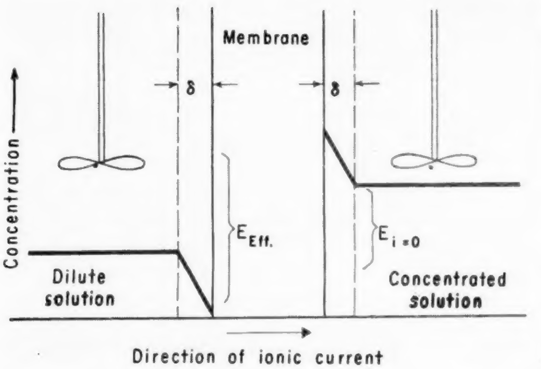
Properties of Cation-Permeable Membranes—Table II

KCl M	Resistance Ohm/Cm²	$\bar{C}^+$ M	$\bar{C}^-$ M	$\bar{D}^+ \cdot 10^7$	$\bar{D}^- \cdot 10^7$	t_+
0.001	28	0.882	0.000	1.0		1.000
0.01	20	0.882	0.000	1.4		1.000
0.1	17	0.889	0.008	1.7	3.2	0.983
0.5	15	0.931	0.050	1.7	3.1	0.914
1.0	8	1.03	0.15	1.8	2.9	0.812

M is the molar concentration.
$\bar{C}$ is the concentration in the membrane phase.
$\bar{D}$ is the effective diffusion coefficient in the membrane.
t_+ is the cationic transfer number.



Gibbs-Donnan equilibrium for ideal cation permeable membrane—Fig. 4



Effect of polarization on a cation permeable resin—Fig. 5

of sea waters). When the membrane in its water-equilibrated sodium form is placed into the salt solution, chloride ions enter the membrane spontaneously, falling down the concentration gradient and generating free energy. Some of this free energy is employed to raise sodium ions from the dilute solution phase to the high concentration level in the membrane, and equilibrium is reached when the net free-energy change is zero. Basic Donnan theory, which neglects deviations from ideal solution behavior, shows that at equilibrium the membrane is 4.09 molal with respect to sodium ions and 0.09 molal with respect to chloride ions or, therefore, that the concentration of *diffusible* sodium chloride is but 0.09 *m* in the membrane while the external solution is 0.6 *m*.

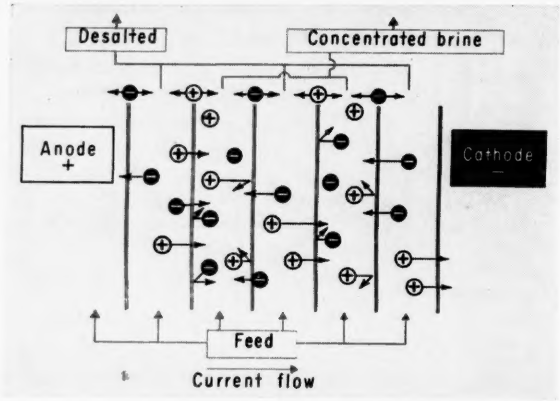
The Donnan equilibrium thus acts to *exclude* electrolyte from the membrane phase. Since the mobile ions within the membrane in Fig. 3 are predominantly cations, when an electric current is passed across the membrane, cations will carry most of the current. It is also evident from Donnan equilibria that when the solution concentration of salt is increased, the ratio of mobile cations to anions within the membranes will approach unity, or the membrane will lose its selective permeability to cations. By the same token, when the external salt concentration decreases, the exclusion of diffusible electrolyte by the membrane becomes enhanced and the ratio of mobile cations and mobile anions approaches infinity. Accordingly, all ion-exchange membranes will show a high selectivity in dilute solutions, a lower selectivity in more concentrated solutions. It is also evident that a membrane usable in concentrated solutions must have a high concentration of fixed charges and that the ohmic resistance of a membrane will be relatively independent of the external salt concentration because its ionic composition changes so little with large changes in solution concentration. Ion-exchange membranes greatly retard the diffusion of neutral salts as such. For example, if a salt solution is placed on one side of a membrane and water on the other, the driving force for the diffusion of neutral salt across the membrane (the only species that can diffuse) will be proportional to the concentration gradient of the *anion*, and will be necessarily quite small.

Table II summarizes some of the fundamental properties of a cation-permeable membrane, taken from the data of Peterson and Gregor.[14] This membrane was available some five years ago and had a fairly high ohmic resistance; membranes of one-tenth this resistance are available today. Table II shows that the molar or bulk concentration of cations within the membrane phase is fairly independent of the external salt concentration and that the concentration of anions increases sharply as the external salt concentration increases. Those systems follow the simple Donnan expression in a qualitative sense only, because activity coefficient corrections are large.

Table III summarizes some of the general properties of membranes presently available. It must be emphasized that a given membrane is not necessarily the best for a specific application. Membranes of particularly low resistance are best for concentrated solutions ($> 0.1\ M$); dilute solution resistances are so high that the resistance of the membrane counts for little by comparison. Further, the pore structure of a membrane may be important for a given application. Some indication of the pore structure of ion-exchange membranes can be determined by measuring the rate

General Membrane Properties—Table III

Thickness	25—250 microns, or 1—10 mils
Water content, Wt. %	10 to 50
Molal conc., m	4 to 8 equiv./1,000 g. H_2O
Transport no., 1 M KCl	0.80 to 0.97



Electrodialysis cell—Fig. 6

of diffusion of ions as well as of neutral molecules of different sizes.

For example, in a typical cation-exchange membrane, the following relative diffusion coefficients were measured:[8] KCl, 55; urea, 23; arabinose, 3.7; glucose, 3.5; sucrose, 1.2; raffinose, 0.1; vitamin B_{12}, 0.00. It is estimated[14] that the pore diameters of most ion-exchange membranes vary from 7 to 12 Å, which should be compared with the estimated diameter of the hydrated potassium ion, which is 4 Å. A fine pore structure is required to maintain membrane selectivity, and it also precludes precipitation within the membrane phase, contamination by colloidal materials, etc. In general, homogeneous ion-exchange membranes have a considerably finer pore structure than do even the fairly highly cross-linked water-treatment resins; in consequence, they show a higher resistance to attack by biochemicals and microorganisms.

Membrane Stability

The chemical stability of ion-exchange membranes, while not as high as that of the ion-exchange resins, is quite adequate for most applications. An extensive survey of the properties of commercially available ion-exchange membranes carried out by Gregor[8] showed that several were capable of withstanding 1-*M* sulfuric acid or sodium hydroxide solutions at temperatures as high as 80 C. for several months without serious deterioration.

Membrane Electrodialysis

In most applications of ion-exchange membranes a direct ionic current is passed through the films, a phenomenon known as membrane electrodialysis. As will be seen later, electrodialysis acts to transfer ions from one solution into another, either with or against a concentration gradient. This passage of current creates a number of interesting phenomena. First, the passage of ions (particularly hydrated ones) through an ion-exchange membrane causes the simultaneous movement of water, a phenomenon knowns as electro-osmosis. Electro-osmotic water transport increases with pore diameter. Fig. 4 shows the electro-osmotic transport of sodium across a cation-permeable membrane where the pore diameter and therefore the water content was increased progressively. For desalting applications, a good membrane will show minimum electro-osmotic water transport, for if the ratio of water to salt passing through the membrane approaches that in the solution being desalted, obviously nothing more than the transfer of solution from one side of the membrane to the other will be accomplished. On the other hand, electro-osmosis can be used to remove water *and* salts from large ions or molecules.

Fig. 5 shows the phenomena that occur when a direct current is passed through a cation-permeable membrane in contact with a salt solution. The effective thickness of the boundary layer (δ) is also shown. As direct current is passed, with cations moving from left to right when the steady state is reached, the flux of anions is zero in the boundary layer and a linear concentration gradient is formed. Solving the Nernst-Planck equation allows steady-state conditions to be calculated readily. This concentration polarization increases with current density, decreases with increased stirring adjacent to the membrane phase (lower δ), higher ion diffusivities and increased solution concentrations (on the polarizing side).

The Bethe-Toropoff Effect

As polarization increases to the point where the wall concentration approaches zero, a phenomenon known historically as the Bethe-Toropoff effect occurs with the forced hydrolysis of water; the hydrogen ions formed move to the right through the membrane, hydroxide enters the solution phase to the left. Those large pH shifts at the membrane faces are highly undesirable for they can induce precipitation and decomposition. Bethe-Toropoff polarization obviously increases the power requirement for the transport process and sets a practical limit upon the current density for a given system. An experimental and theoretical treatment of this phenomenon has been carried out.[8] In theory, this phenomenon could be used to produce acids and bases.

The influence of the rate of stirring upon the occurrence of polarization is not pronounced. Gregor[9] measured the thickness of the boundary layer under a variety of experimental conditions and found that in open channels at a Reynolds number of about 2,000 δ was 100 microns, while increasing the Reynolds number to 5,500 lowered δ to 28 microns. Accordingly, high rates of stirring and high pumping costs are required to reduce δ markedly.

It is evident that in ion-exchange membrane electrodialysis, as in all other separation processes, an increase in the rate for a device of given size must give rise to an increased inefficiency in terms of power costs. As shown in Fig. 5, the required voltage rises from $E_{i=0}$ to E_{eff}. Polarization gives rise to pH shifts, and other undesirable effects occur. These can be mini-

mized only by carrying out the process at reasonable current densities. For any given rate of production, a decrease in current density must call for an increased investment cost.

In electrodialysis equipment, it is estimated that about one-half of the *entire* cost of the process, including investment, power, etc., is that of the membranes themselves. It is evident that a desirable membrane must have a low ohmic resistance, a high ionic selectvity and, at least of equal importance, a low cost. At the present time, commercially available membranes sell for approximately $1/sq. ft. in large amounts; one manufacturer has claimed a projected membrane price of 35¢ on large production.

An electrodialysis cell is shown in Fig. 6, where a direct current is passed across a stack of alternating cation-permeable and anion-permeable membranes, and where concentration and desalting occur in alternate cells. The equipment used is similar to a filter press with solutions flowing across the membrane faces from a system of through-ports. Gregor has described the fabrication of simple laboratory cells and multiple electrodialysis cell similar to large-scale equipment for continuous operation.[8]

The desalting or concentrating capacity of an ion-exchange membrane unit can be estimated from a knowledge of the maximum permissible current density. For example, a stack having a volume of 1 cu. ft. with a spacing of 0.05 in. between membranes, or 0.1 in. for each cell or membrane pair, will have a desalting or concentration capacity at the low current density of 10 amp./sq. ft. of 4 lb. of sodium chloride per hour; at a current density of 40 amp./sq. ft. as is allowed in more-concentrated solutions, a capacity of 16 lb. of salt per hour is obtained. It is evident that ion-exchange membrane systems have a very high capacity in terms of salt removal or concentration, contrasted with the relatively low capacity of ion-exchange resin systems.

The two processes complement each other; the resins are efficient for the removal of relatively small amounts of material from large volumes of solution, while membranes are efficient for the removal or concentration of a large amount of material from relatively concentrated solutions. As an approximation, at concentrations above .01 *M*, the membranes are more efficient; at concentrations below .01 *M*, the resins are more efficient.

Applications of Membrane Systems

The many properties of ion-exchange membrane systems suggest that innumerable applications in the chemical industry will develop. The desalting of sea and brackish waters has been accomplished. At the present time, it appears that with current membrane costs, the ion-exchange membrane process is not competitive with other desalination processes for the desalting of sea water. It is, at present, the best process for the purification of brackish waters in the 1,000 to 10,000 ppm. range. It is estimated that electrodialysis units can desalt average brackish water at a total cost (including investment and maintenance) of 25¢/1,000 gal.

In the chemical industry, solutions can be desalted, electrolytes can be concentrated, streams can be purified, and waste streams can be concentrated for easier disposal. For example, the production of sodium chloride from sea water is carried out on a large industrial scale in Japan. Sea water (3% salt) is concentrated to 18% or even to the point of saturation (26%). For this application, it is reported that membrane electrodialysis is more economical than such concentrating processes as evaporation and freezing.

Special Uses

Among the many special applications of ion-exchange membranes has been their proposed use in chlorine-caustic cells where membranes permeable only to sodium ions would allow the preparation of chloride-free caustic solutions. However, it is difficult to obtain a membrane that has a high selectivity in concentrated solutions and will withstand the corrosive conditions prevailing. On the other hand, the concentration of sulfuric acid from dilute solutions up to those 20% and higher in composition has been achieved.[8] This suggests, too, that acid pickle-liquors and other similar streams can be treated by ion-exchange membranes.

These membranes can similarly be employed to separate ionic from neutral molecules. For example, it was shown earlier that the diffusion coefficient of potassium ions in a membrane was but twice that for urea, a particularly mobile non-electrolyte. An attempt to separate these two species on the basis of a diffusive process across the membrane would obviously be inefficient, but the imposition of an electric field makes a quantitative separation entirely feasible.

One can also separate materials having different degrees of ionization. For example, an excellent separation of many amino acids from one another has been achieved, including the separation of lysine from arginine and histidine.[8] The quite difficult separation of proline from hydroxyline, two extremely similar amino acids, has also been performed.[8] Those separations are by no means as sharp as those achieved by resin chromotography; with the resins, one obtains milligram amounts of extremely pure materials, while a small membrane unit can produce kilogram amounts of materials with a reasonable degree of purity.

It is of interest also to consider the possibility of employing ion-exchange membranes for the direct ultrafiltration of salt from saline solutions, a process also known as reverse osmosis. Extensive work by Ried and others has shown that certain plastic films, notably cellulose triacetate, are capable of screening out electrolytes while being permeable to water. The imposition of a direct hydrostatic-pressure sends water through the membranes with a good level of desalting but with an extremely low throughput.

With sea water, the equilibrium pressure is 400 psi., with working pressures of 800-1,000 psi. being required. Ion-exchange membranes also act as ultra-

filters, because a membrane impermeable only to either anions or cations will be impermeable to both by the electroneutrality requirement. A comparison of the rate of ultrafiltration through ion-exchange and cellulose triacetate membranes suggests that the former possess a superior potential for this application.

Little information is available on the possible use of ion-exchange membranes in nonaqueous media or ones containing relatively small amounts of water. The Donnan requirement suggests that the applicability of ion-exchange membranes under those circumstances will be limited, but direct experimental work is needed to confirm this.

Many questions have been asked concerning the extent of prior art in the field of ion-exchange membrane electrodialysis. An examination of the extensive literature shows that ion-exchange membrane technology is very old indeed, predating ion-exchange resin technology by many years. Electrodialytic desalting by the use of cation- and anion-permeable membranes was proposed before the turn of the century; units were in operation and patents applied for shortly after World War I. However, the membranes available at that time possessed a low ionic selectivity and a high ohmic resistance—and were highly unstable. Ion-exchange membrane electrodialysis became practical as a result of the pioneering work of Sollner, who prepared the first Permselective membranes, ones of high permeability and selectivity. The old and extensive background in this field suggests that the general applicability of ion-exchange membranes will not be restricted by patent considerations.

References

1. Skogseid, A., "Some Derivatives of Polystyrol," Thesis, Oslo, Norway, 1948.
2. Chen, C. H., Dissertation, Polytechnic Institute of Brooklyn, N. Y., (1957).
3. Gregor, H. P., others, *Ind. Eng. Chem.*, **44**, 2834 (1952).
4. Miles, H. T., others, *J. Am. Chem. Soc.*, **76**, 4041 (1954).
5. Forkos, J., others, *J. Polymer Sci.*, **53**, 338 (1961).
6. Menecke, G., *Z. Elektrochem.*, **57**, 189 (1953).
7. Gregor, H. P., Beltzer, M., *J. Polymer Sci.*, **53**, 125 (1961).
8. Gregor, H. P., others, to be published.
9. Arnold, B. B., Murphy, G. W., *J. Phys. Chem.*, **65**, 135 (1961).
10. Gregor, H. P., others, *J. Phys. Chem.*, **59**, 19 (1955).
11. Hechter, O., others, *J. Am. Chem. Soc.*, **81**, 3798 (1959).
12. Kraus, K. A., Phillips, H. O., *J. Am. Chem. Soc.*, **78**, 249, 694 (1956).
13. Bieber, H. H., others, *Ind. Eng. Chem.*, **50**, 1273 (1958).
14. Peterson, M. A., Gregor, H. P., *J. Electrochem. Soc.*, **106**, 1051 (1959).

Meet the Author

HARRY P. GREGOR *is professor of chemistry at the Polytechnic Institute of Brooklyn. He has a B.A. and a Ph.D. from the University of Minnesota.*

In addition to his academic career, Dr. Gregor has industrial experience as a research chemist for The Permutit Co.

He has long been interested in ion-exchange materials, and was the first to make an ion-exchange membrane.

CONFERENCE REPRINTS AVAILABLE

Reprints on the entire series of articles on New Trends in Chemistry will shortly be available. The price of this 13-article, 108-page reprint is $2 per copy, subject to quantity discounts.

For fastest service check No. 197 on your Reader Service Card in this or any subsequent issue.

The articles appeared in CHEMICAL ENGINEERING issues of the following dates:

October 16, 1961
High-Temperature and Plasma Chemistry, *J. L. Margrave*

High-Pressure Chemistry, *R. H. Wentorf, Jr.*

October 30, 1961
The Organic Semiconductor Challenge, *H. A. Pohl*

Chemical Kinetics—Expanding Field, *M. Kilpatrick*

Inorganic-Polymer Chemisty Points Way to High-Temperature Plastics, *G. Barth-Wehrenalp*

November 13, 1961
Solid-State Chemistry Gives Insight Into Crystal Behavior, *F. V. Schossberger*

Non-Aqueous Solvent Systems, *J. J. Katz and I. Sheft*

Irreversible Thermodynamics, *R. J. Tykodi*

November 27, 1961
New Data on Metal-Complex Formation, *A. E. Martell*

Catalysis, *V. Haenset*

December 11, 1961
Progress in High Polymer Science, *H. F. Mark and S. M. Atlas*

December 25, 1961
Is Radiation Chemistry Practical?, *P. Y. Feng*

Using Ion Exchange Resins and Membranes, *H. P. Gregor*

Apply Fluidization to Gas Humidification

In this proposal for an adiabatic gas humidifier-cooler, a relatively shallow bed of fluidized solids provides the contact surface for saturating a gas with a given vapor.

NORMAN EPSTEIN, *University of British Columbia*

A new approach to gas humidification is possible by applying fluo-solids contacting techniques. Although, two recent books[2,6] on fluidization discuss scores of applications of this technique to a wide variety of physical, chemical and metallurgical operations, there is no mention of any application of fluidization to gas humidification. Nor is there mention of this use in the large fluidization literature that has come to my attention.

This article shows how to apply fluidization techniques to gas humidification and the appropriate special measures necessary to effect it. By humidification, we mean the enrichment of any gas with the vapor of any liquid. While in practice the gas is often air and the liquid water, the term humidification as used here is not confined to any particular gas or liquid.

The basis for this proposal is the well-demonstrated fact[1,2,4,6] that in a dense-phase gas-fluidized bed, both thermal and diffusional equilibrium between the surface of the particles and the gas is established within a very short distance of the inlet gas distributor. This distance is usually less than 1 in. and almost invariably less than 3 in.

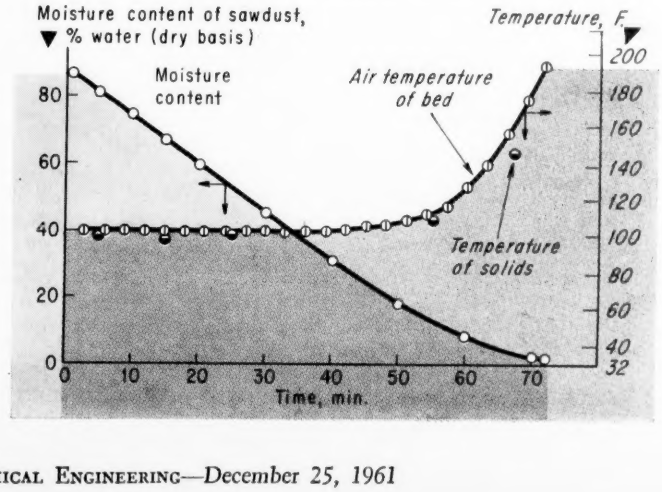
This means that when the fluidized solids are undergoing constant-rate drying, at liquid compositions in excess of critical, the gas will be saturated with the vapor of the evaporating liquid, provided only that the bed depth exceeds the small value of 1 to 3 in. (For water removal, the liquid composition is known as the "critical moisture content.")

Furthermore, in the absence of external heating or cooling, both the outlet gas and the well-mixed solids will be at the adiabatic-saturation temperature of the incoming gas. In other words, the gas will follow an adiabatic cooling line to saturation in passing through the fluidized solids undergoing constant-rate drying.

These statements are exemplified by the fluidized drying of a −4-mesh screened hemlock-and-cedar sawdust, from British Columbia, in a 12-in. lagged steel column. Experiments were carried out by me at the Applied Chemistry Div. of the National Research Council of Canada during the summer of 1954.

Batches of sawdust containing up to 95% moisture on a dry basis were fed to the column and dried with metered hot air that was distributed through a 20-gage steel grid containing 112 holes, having $\frac{1}{16}$-in. openings. Shielded thermometers, including a wet-bulb and a dry-bulb at the exit, were used to probe the column at

Determine critical moisture content of solids—Fig. 1



Initial conditions for test run.

Fluidized drying curves for cedar and hemlock sawdust.

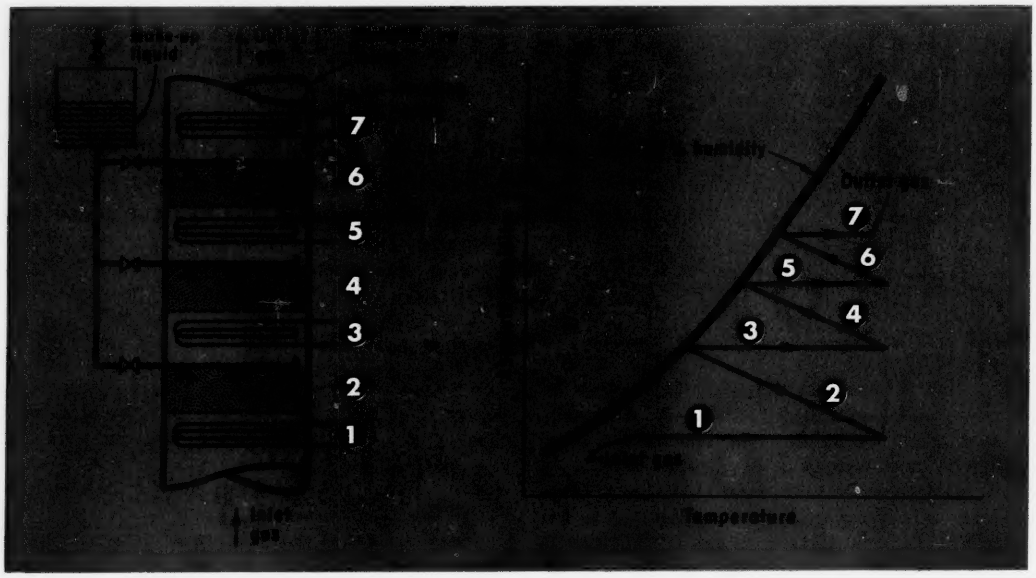
Inlet air rate = 494 lb./hr.

Inlet air temperature = 306.1 F.

Inlet air humidity = 0.002 lb. water / lb. dry air.

Bed weight = 25.8 lb. dry sawdust

Gas humidification may require multistage unit—Fig. 2



various points. Sawdust samples were taken at frequent intervals for moisture-content analysis as well as for the measurement of solids temperatures.

For each run, a constant-rate drying period occurred, throughout which both sawdust and bed-air temperatures (including exit air) were constant and equal to the adiabatic-saturation temperature of the inlet air, while the exit air was saturated with water vapor. Neither horizontal nor vertical temperature gradients were observed in the beds. The sawdust thermometer was located 4 in. above the air-distribution plate.

Thus, the constant evaporation rate was in each case dependent only upon the condition and rate of the inlet air and was independent of bed weight or depth, which affected only the duration of the constant-rate period. The end of the constant-rate period was in every case marked by a sharp rise in bed-air temperature, with the sawdust temperature also rising, though lagging behind the air temperature. Throughout the course of a run, the column back-pressure kept decreasing because of the decreasing moisture content of the fluidized solids.

Test Run Proves Theory

Data for a typical run are shown in Fig. 1. For this run, the bed depth during fluidization was about 60% greater than the original settled-bed depth of 4 ft. During the constant-rate period, which extended down to a moisture content of 30% (dry basis), the bed-air temperature was perfectly constant at 104 F., the adiabatic-saturation temperature of the inlet air.

The fact that the recorded solids temperature was slightly lower than the bed-air temperature can be attributed completely to the negative error arising from heat loss during sampling of the sawdust and during equilibration of the thermometer with the sawdust sample. The rate of water evaporation as determined from the constant-rate portion of the sawdust-drying curve is 0.046 lb. water/lb. dry air, a value that agrees well with 0.047 calculated from the assumption that the air followed an adiabatic humidification path to saturation.

A very simple method for continuously saturating a gas with a given vapor emerges from these observations. It is necessary only to maintain, at a constant value above the critical, the liquid content of a fixed charge of solids undergoing dense-phase fluidization. This is done by introducing liquid to the charge at the same rate at which it is being vaporized. Hence, we ensure that the fluidizing gas becomes saturated with the vapor of this liquid. The bed depth need only exceed a few inches.

The solids being fluidized should preferably be of low density to minimize pressure drop; of high internal porosity to ensure a wide range of liquid composition above the critical; and of not too wide a size distribution. And, in order to minimize particle entrainment, the solids should not be subject to easy attrition.

The sawdust of the above example (specific gravity = 0.4), with its fines removed and its moisture content maintained at about 50% (dry basis), would fulfill these requirements probably as well as or better than any other solid material, at least where water is the evaporating liquid. A settled-bed depth of 5 in., fluidized to a depth of about 8 in., would require a total pressure drop of only 2 in. of water. About half of this drop would be due to the weight of sawdust supported, while the other half would be assigned to

a gas distributor having a high but feasible porosity.

As in our example, assume a superficial gas velocity of 2.5 ft./sec., and an additional column height of 10 in., to minimize particle entrainment. Then, for a given gas load, the resulting volume of the unit would be similar to that of a spray chamber.[3] The decrease in length relative to a standard spray chamber would be approximately equal to the increase in required cross-section.

Advantages of the Fluo-Solids Humidifier

The primary advantage of the unit compared with a conventional spray chamber, which also has low pressure drop, is that the proposed unit does not require liquid recirculation. In a spray chamber, the continuous recirculation rate of liquid is some 10 to 100 times the rate of liquid actually vaporized. In this chamber, the make-up rate required to maintain steady-state conditions equals the vaporization rate.

In the present unit, the mass-transfer equivalent of liquid recirculation is furnished by the fluidized solids. Their liquid content is kept above the critical content and their surface area provides the liquid-gas interface, which in the spray chamber is supplied by the atomized drops of recirculating liquid. Thus, the substantial power expenditure required to maintain liquid circulation in a spray chamber is avoided in the present equipment.

Make-up liquid to the fluidized solids can be added by any one of a number of standard liquid distributors[5] located at the top of the expanded bed. A simple perforated pipe would be more than adequate for the present purpose, especially in view of the relatively small trickle of liquid that would normally be required and the excellent blending characteristics of the fluidized bed itself. In the test unit, the make-up rate was 220 $cm.^3$/(min.) (sq. ft. of bed cross-section).

As in a spray chamber, adiabatic humidification of the gas presupposes that the make-up liquid enters at the adiabatic-saturation temperature of the inlet gas. But in most cases the quantity of evaporation would be so small, relative to the total holdup of solids and their liquid content, that minor deviations from the adiabatic-saturation temperature for the make-up would have little effect on the humidification path of the gas.

The required make-up rate could be computed from a knowledge of the inlet gas rate, humidity and temperature, using a psychrometric chart for the given gas-liquid system. This computed rate would have to be maintained as an average over a long period of time. However, due to the large span of permissible liquid content above the critical, considerable fluctuations from this average could be tolerated without in any way affecting the gas humidification.

In the moist sawdust example, an acceptable quality of fluidization could be maintained up to a moisture content of 100% (dry basis). As the pressure drop across the proposed sawdust bed would increase (due to weight gain of the bed) by about ½-in. of water over the permissible moisture content range of 30 to 100% (dry basis), differential pressure could be utilized to control the rate of make-up water. Such control would be particularly appropriate at the less-pronounced upper limit of acceptable moisture content, above which the sawdust gets too soggy to fluidize properly.

At the lower limit, below which the gas no longer describes an adiabatic-humidification path and does not leave saturated, the sudden rise in temperature of the exit gas at the beginning of the falling-rate drying period can be utilized to institute a finer control on make-up liquid rate than that furnished by differential pressure.

Cooling of the gas accompanies adiabatic humidification. In fulfilling particular gas conditioning requirements, this cooling effect may have to be taken into account. As is the case for a spray chamber, preheating, afterheating or both may be necessary for the gas undergoing humidification. On the other hand, this cooling effect may be the primary purpose of the process especially for room-temperature air.

Sometimes, several stages in series of alternate heating at constant humidity and adiabatic humidification may be required to effect a desired humidity, and possibly temperature change, without excessive heating of the gas at any one stage. Such a multistage fluidization, along with the accompanying psychrometric paths followed by the gas, is illustrated schematically in Fig. 2.

Unlike a spray chamber, a one-stage fluidization unit with bed depth in excess of 3 in. can produce 100% humidity gas at the adiabatic-saturation temperature if the column is adequately insulated. If less than this degree of humidification cooling is desired, then an appropriate proportion of inlet gas can be bypassed to meet the outlet gas. The amount to be bypassed can be computed stoichiometrically and controlled by means of outlet humidity or temperature.

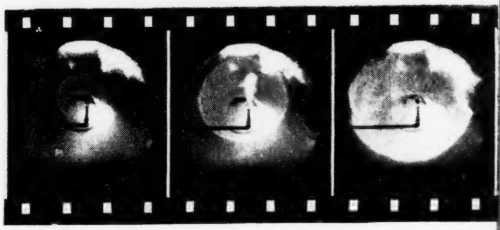
References

1. Heertjes, P. M., de Boer, H. G. J., de Haas van Dorsser, A. H., *Chem. Eng. Sci.*, **2**, 97 (1953).
2. Leva, Max, "Fluidization," McGraw-Hill, New York, 1959.
3. Perry, J. H., "Chemical Engineers' Handbook," 3rd ed., p. 778, McGraw-Hill, New York, 1950.
4. Richardson, J. F., Ayers, P., *Trans Instn. Chem. Engrs.*, **37**, 314 (1959).
5. Treybal, R. E., "Mass Transfer Operations," p. 138, McGraw-Hill, New York, 1955.
6. Zenz, F. A., Othmer, D. F., "Fluidization and Fluid Particle Systems," Reinhold, New York, 1960.

Meet the Author

NORMAN EPSTEIN *is associate professor of chemical engineering at the University of British Columbia, Vancouver, Canada. On sabbatical leave during the current academic year, he is at the department of chemical engineering, Cambridge University, England. He received a B.E. and an M.E. in chemical engineering from McGill University and a D.E.S. from N.Y.U. Dr. Epstein has written articles on the various aspects of momentum, heat and mass transfer.*

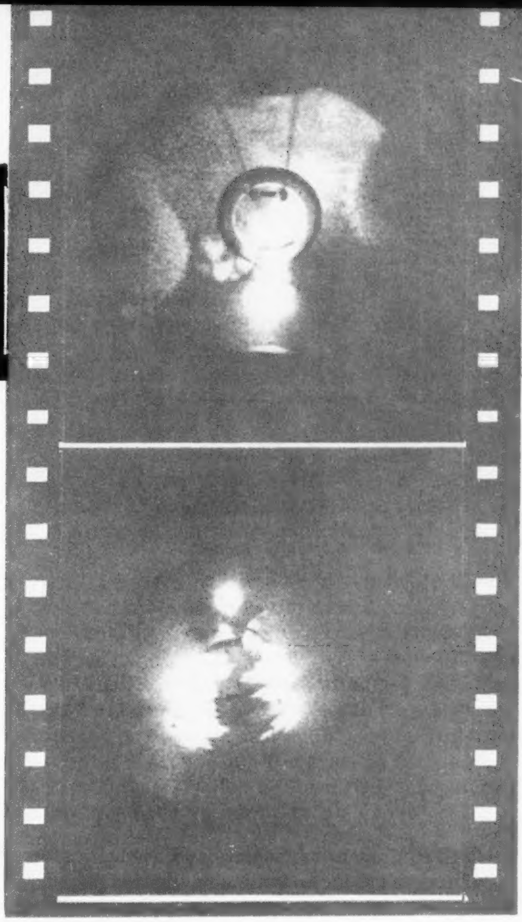
Unsuppressed blast in test chamber, shown in high-speed photos, rapidly expands from ignition (left) to fill the entire chamber (right). Elapsed time is 50 milliseconds.



Explosion Suppression: New Safety Tool

Split-second suppression system, coupled with conventional explosion prevention methods, minimizes potential hazard.

CLAYTON B. HAMMOND
Monsanto Chemical Co.



Suppressed explosion is quickly enveloped by clouds of extinguishing mist. Suppressant bottles, mounted at each side of chamber, discharge within a few milliseconds after ignition of the charge.

Many chemical process industries have an inherent potential for fire and explosion.

But, at its Plastics Div. in Springfield, Mass., Monsanto Chemical Co. has minimized this potential with a combination of explosion prevention, explosion control and a new explosion-suppression system.

Explosion suppression represents an active rather than passive approach toward greater explosion protection. It consists of detecting the explosion and suppressing or extinguishing it before it reaches a critical point. Because of success with a pilot installation, Monsanto has installed three more of these systems, a fourth is in the design stage, and others are under consideration.

Monsanto's Springfield plant produces 215 plastic formulations from organic chemical raw materials in gas or liquid form. Among these chemicals are styrene and vinyl monomers, which present definite fire and explosion hazards prior to their conversion to commercially usable plastic materials.

Explosion Theory Reviewed

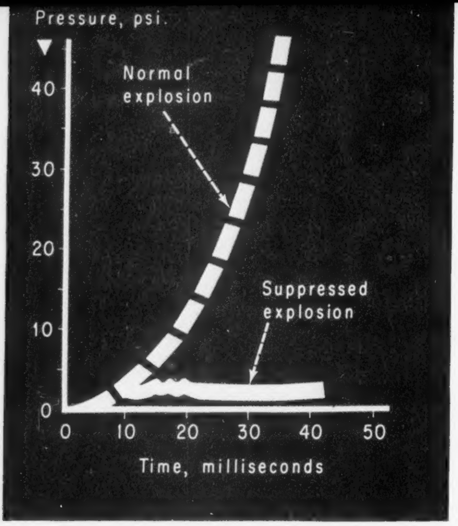
An explosion is really nothing more than an extremely fast fire, characterized by the rapid release of energy. Like a fire, it has three essential ingredients—a combustible material, oxygen and a source of ignition. In addition, for a fire to become an explosion, it must occur within a confined volume, and the combustible material must be in the form of fine particles—fine dust in suspension in the case of a solid material, vapor in the case of a flammable liquid—distributed in flammable concentrations throughout the volume.

The two primary physical effects of any explosion are heat and pressure, and the latter presents the greater hazard to personnel, structures and equipment. Although an explosion flame is of high intensity, it is of extremely short duration and is not a great problem, except for the possibility of its igniting a secondary fire or explosion.

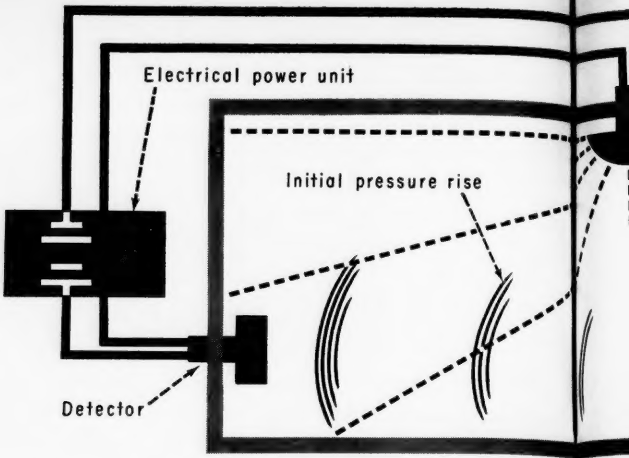
The type of confinement of the hazardous material greatly influences the extent of the hazard. In general, the greatest danger exists in small vessels, rooms or buildings because it is difficult to obtain suspension of particles in larger vessels. Also, the larger confined volume can absorb more pressure buildup, and is somewhat self-venting.

Particle size also affects explosion hazards—the smaller the particle, the more easily it is suspended in air, and the more easily it is ignited.

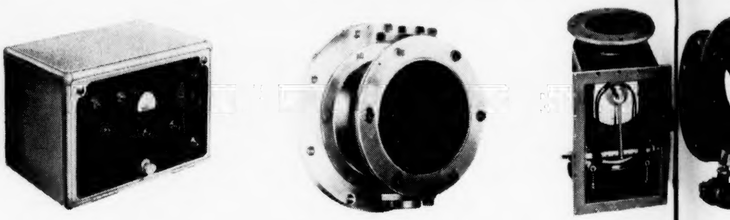
The hazard of vapor explosion exists in such gas-



Pressure buildup is kept to 1-5 psi.—Fig. 1



Standard system components are shown at right—Fig. 3



Power unit with standby batteries

Pressure sensitive explosion sensor

High-speed val for isolation

Explos actuate

fired equipment as burners and ovens, in storage tanks, and areas where flammable liquids are handled. In general, gases are more easily dealt with than dust because they are handled in closed systems. Thus, it is usually possible to exclude potential ignition sources and design the equipment to contain explosive pressures.

Although theoretically less violent than a vapor explosion, the practical result of a dust explosion is about the same. Dust explosions are much more difficult to prevent or control because the processes in which dust is created are seldom completely enclosed. Grinding, crushing, conveying and drying are often involved, and enclosure of such equipment in pressure-resistant structures, if possible at all, would be prohibitively expensive.

Explosion Prevention

The fundamental method of preventing explosions is to avoid the simultaneous occurrence of fuel, oxygen and ignition source.

Ignition temperature and energy requirements vary widely, and some materials require very little energy to react. Therefore, open flame, static electricity and other potential sources of ignition must be eliminated. Electrical equipment should conform to the National Electrical Code and to local regulations. Proper installation and maintenance are also important.

Preventing accumulation of combustible material is primarily a matter of housekeeping. Buildings and equipment should be regularly washed and vacuumed, but caution is required when cleaning dust accumulations. Turbulence created by high-pressure hoses can cause dust suspension in the air and create an explosive condition. Vacuum systems pose severe static discharge problems, and should be well grounded, with the grounds tested frequently.

At Springfield, we have developed techniques to simplify cleaning and call attention to poor housekeeping. Ledges, nooks and crannies where dust might accumulate have been eliminated as much as possible. For example, I-beams are boxed with sheet metal, and dust-prone surfaces are painted with a color contrasting to that of the dust being handled.

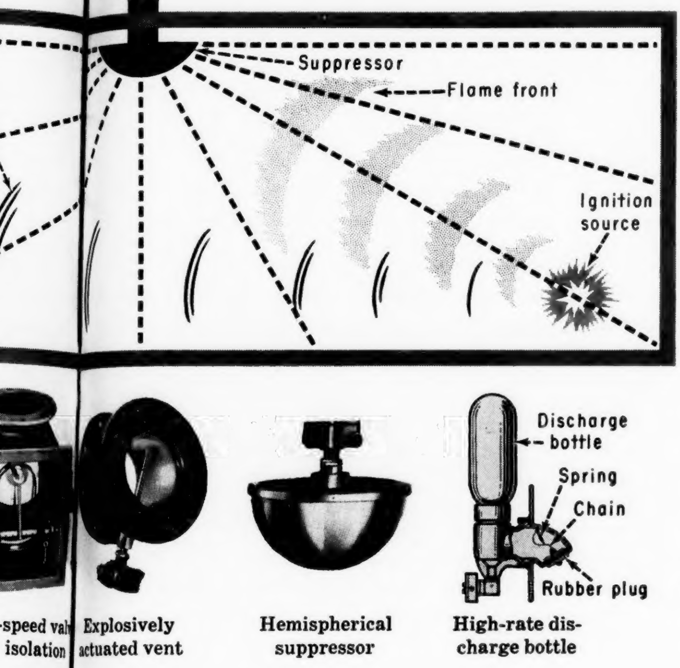
Elimination of oxygen is more difficult and may be limited by the process under consideration. Inert gases can be used to blanket flammable liquids in a closed system, and an inert inorganic material, such as rock dust, can be added to the system where a dust hazard occurs.

Explosion Control

Control of an explosion's effects is the second conventional step. Until recently, it was the final step, and the only one designed to deal with the explosion itself upon failure of the preventive measures. The basic technique is to vent the area or equipment to allow safe release of pressure and heat to the surrounding atmosphere.

Many factors must be considered in the selection of suitable vents. The first is the strength of the structure enclosing the hazardous area. A heavy masonry wall, for example, will withstand pressures up to 10 psi., but maximum explosion pressures will almost always exceed this figure—a typical plastic dust explosion can develop 100 psi.

Basic suppression system consists of sensor and suppressor—Fig. 2



Position of the vents relative to the point of potential explosion is also important. They must be located so that the pressure will reach them in a direct, unobstructed line—explosive pressures don't turn corners.

Empirical methods for computing venting requirements have been developed, based generally on strength of building materials, volume to be vented and explosion characteristics of the combustible material. For less-critical problems, there are ratios of venting area to volume of enclosure that are based on generally accepted practice (National Fire Codes, Vol. II, Combustible Solids, Dusts, Chemicals and Explosives, National Fire Protection Association, Boston, 1959, Section 68).

Explosion Suppression

In 1959, we installed a pilot explosion-suppression system at the Springfield plant. Developed in Britain, this system was introduced in the U.S. by Fenwal Inc., Ashland, Mass.

The system operates on the basis that, although an explosion appears to be instantaneous, there is a lapse of time between ignition and buildup of destructive pressures. This time is in the order of several thousandths of a second. The system senses the explosion and takes action before pressures become destructive.

Fig. 2 shows a schematic of the basic suppression system and Fig. 1 shows a graphical comparison of pressure buildup vs. time for a normal and for a suppressed blast. The lead illustrations compare suppressed and unsuppressed explosions with high-speed photographs.

The explosion detector, which is the heart of the system, can be either a pressure-sensitive device or a radiant-energy detector. The pressure detector is sensitive to either the rate of pressure rise or to a specific static pressure, or both. The radiation detector selectively senses certain wavelengths of the spectrum that exist in an explosive flame.

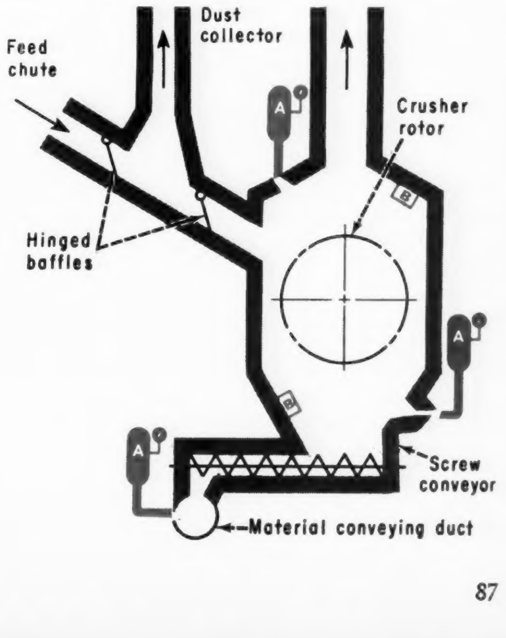
The detector signals the power unit, equipped with stand-by batteries in case of power failure, which activates the various explosion-protection devices. All of these devices are operated by explosive detonators similar to the precision electric blasting caps used in seismic exploration. The actions performed include suppression of the explosion, venting of the confined space, isolation of the explosion, advance inerting of associated areas, and automatic shutdown of equipment or plant.

There are two types of suppressor—easily ruptured hemispherical containers, or high-rate discharge bottles. Both contain a liquid suppressant that is dispersed in fine particles at speeds up to 600 ft./sec. The incipient explosion is cooled by heat of evaporation of the enveloping mist, thus inhibiting further combustion. Only small quantities of suppressant are required because of its high discharge rate. For example, only 5 cc. of water or 2 cc. of bromochloromethane are required to suppress an explosion in a 1-gal. volume.

System vents are glass windows that are fractured by an explosive detonator mounted against their outer face. The elevated pressure within insures that glass fragments will fly outwards, away from the protected space and process.

Isolation is secured with butterfly or flap valves that are held open against heavy spring pressure by

High-rate bottles (A) and pressure sensors (B) protect hammermill—Fig. 4



a hollow metal link. A detonator within the link breaks it, allowing the spring to slam the valve closed. Fig. 3 shows standard system components, including a modified discharge bottle described below.

A Pilot Installation

Our first system was installed in a hammermill that crushes large pieces of plastic. As in any crushing operation, this one is very dusty, and the plastic dust is combustible. Also, it is virtually impossible to prevent tramp metal from entering the system and causing sparks when struck by the hammers.

Fig. 4 shows schematically how the suppression system is installed in the crusher hammermill. Four pressure-sensitive explosion detectors are installed in the crusher chamber, two above and two below the rotor. Four externally-mounted high-rate discharge bottles protect this space. A fifth is mounted to inert the product-conveying duct and prevent transmission of an explosion through it. The crushing chamber is vented to atmosphere through a 28-in. duct, leading from the top of the chamber through the building roof. Hinged baffles in the feed chute afford some protection to the dust collector and the operating area.

Initially, we installed hemispherical suppressors in the crusher because they would discharge more quickly. But they could not withstand the constant impact from flying pieces of plastic, and we replaced them with high-rate bottles containing bromochloromethane suppressant.

To prevent plastic dust from collecting and fusing in the nozzles, special nozzles and plugs were designed, as shown in Fig. 3. The plugs are designed to blow out easily upon discharge of the bottles. All five suppressant bottles can operate simultaneously from any two detectors.

The system demonstrated its effectiveness on May 27, 1960, when a dust explosion occurred in the crusher. The explosion occurred just before the equipment was to be shut down. The operator was standing at the control panel as the plastic hit the crusher hammers. He saw a flame above the crusher followed by black smoke. Other personnel saw the flash, followed by smoke and fumes originating from the explosion suppressant. The pressure developed by the explosion was contained within the crusher and released through the vent. The baffle arrangement in the feed chute apparently minimized discharge of pressure and plastic through it. Total damage to the crusher itself was deformation of the access plate in the lower part of the feed chute.

A flame passed through the dust-collector duct and entered the bag collector on the roof, which was not protected by the suppression system. Above the roof line, where it makes a 90° turn, the duct was blown open. A secondary flash in the collector vented itself through the side panels and was extinguished. There was no major damage to the collector, and the duct and side panels were easily replaced.

The source of ignition could not be determined, but it is assumed that a tramp-metal spark was probably the culprit. Careful search of the crusher after the explosion turned up small quantities of metal chips in the equipment.

Based upon the appearance of the equipment, the maximum pressure attained was 4-5 psi. If unsuppressed and uncontained, an explosion of this type could reach a maximum pressure of 65-100 psi.

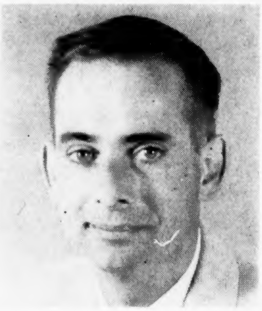
Ideally, the suppression system should limit maximum pressure to 1-2 psi. However, the ignition appeared to have occurred in the upper section of the chambers, and the detectors there had been disconnected pending a revision necessitated by the extreme vibration of the unit. Thus, the pressure buildup had to be sensed by the detectors in the hopper below the rotor. This slight lag, coupled with the slower action of the discharge bottles that had been substituted for the hemispherical suppressors, probably accounts for the slightly greater than ideal pressure experienced in this case.

Nevertheless, the investigating engineers concluded unanimously that the protection system had been effective in limiting the pressure buildup to a safe level, and similar systems were immediately installed on two other plastic crushers.

The investigating group also recommended a number of minor changes, although the basic system itself remains the same. For example, the electrical controls of the crusher motor, conveyor screw, crusher feeder and collector fan, and dust collector fan have been interlocked with the suppression system for automatic shutdown when the suppression system is activated.

Although our experience shows the effectiveness of the suppression system and its value in some applications, it does not replace the protection methods previously used. Such practices as venting, good maintenance and plant housekeeping are still necessary to prevent and control explosions.

Meet the Author



CLAYTON B. HAMMOND *is superintendent of the engineering section in the plant engineering department at Monsanto Chemical Co.'s Plastic Div. plant in Springfield, Mass. He joined Monsanto in 1951, following his graduation from Norwich University where he received a B.S. in mechanical engineering. Hammond started as an area engineer and attained his present position in 1959. He is a member of ASME.*

Chemical Engineers Look for More Help in Finding New Jobs

Recent* CHEMICAL ENGINEERING *survey shows that employment centers at AIChE meetings would be welcomed, but that engineers may not be aware of currently existing aids.

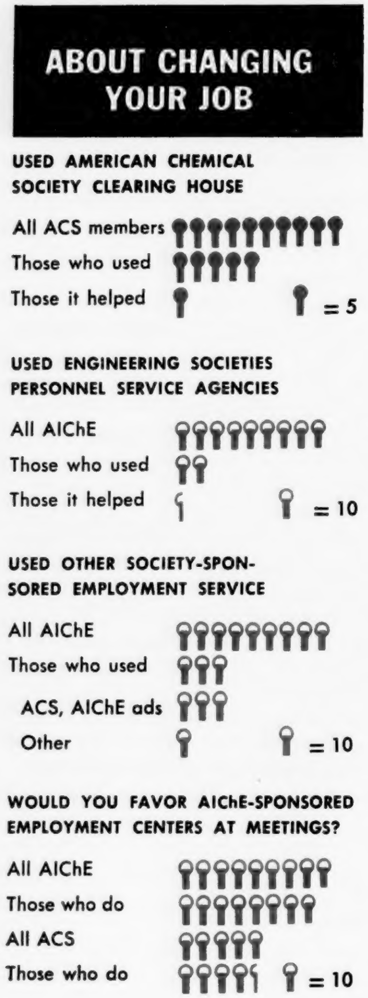
Will your next move be easy to make? To that question, one engineer—a veteran of 14 years in the process industries—answered, "I seem to have no job mobility; I feel trapped."

Responding to a recent request in these columns (*Chem. Eng.*, Oct. 16, p. 204), 124 other readers—most of them members of AIChE and/or ACS—filled us in on the frustrations and satisfactions of carving out an engineering career path in industry today. The men who responded work in most segments of the process industries—from "chemicals and petrochemicals" (33) to "stone, clay, glass and ceramics" (1).

In age, the respondents to the job-mobility survey range from two youngsters just out of school to two old timers of 30-35 years experience. By far the greatest number of them fall in the 30-40 age group. Over half have been with their present firm five years or less; just half have had either one or two previous jobs. To make their last job change, they chose, nearly equally, five or six methods of contact with employers. Major reasons for their last change: wanted more opportunity or responsibility; had been laid off; wished to change industry, function or location; desired higher pay.

Those are some highlights from the job-mobility survey. Details follow in tables and charts on the succeeding pages. Several important points can be gleaned from the figures and from comments of the respondents:

- AIChE members do not seem aware of the range of employment services that is available to them.
- Most AIChE and ACS mem-



bers who replied favor AIChE-sponsored employment centers at Institute meetings.

• Most who have used such well-known services as the ACS clearing house and the Engineering Societies Personnel Service, Inc., (ESPS) have not found them helpful in gaining a job.

Some Present Job Helps

That AIChE members may not be fully aware of what help is now available to them from their society is apparent from suggestions of those who favored more AIChE-sponsored employment services. Many of them named areas that a full-time, experienced staff man at the Institute now administers. His major services include, besides sitting on the board of ESPS, assembling two bulletins—"Situations Wanted" and "Openings for Chemical Engineers."

The first bulletin is a preprint of notices that appear in *Chemical Engineering Progress*, an official AIChE publication. Members are permitted two such free notices annually. Mailed first-class to any personnel men or other executives who request it (there are now 3,200 on the mailing list), the preprint stimulates inquiries from job-offerers before the magazine is mailed. The October bulletin, for example, produced 420 such inquiries within 10 days of mailing, which were forwarded by AIChE to the 29 listed chemical engineers.

A newer service, "Openings for Chemical Engineers," was just started in October. Containing brief descriptions of jobs offered by recruitment advertisers in *Chemical Engineering Progress*, this free bulletin also is mailed before the magazine. It goes to members who are looking for a job—as indicated by situation-wanted notices filed with the Institute—as well as local-section officers and others.

Both these bulletin services protect the job-seeker until he decides to follow up specific interest shown by an employer. And AIChE quickly transmits (same-day service) data between the two parties.

Peripheral services at AIChE's national headquarters include an up-to-the-minute listing of job openings, and a list of employment agencies and recruitment firms that might be interested.

One other service is the Engineering Societies Personnel Service, Inc. A nonprofit employment agency run by the "founder" societies—including AIChE—it operates out of New York, Chicago and San Francisco offices. You can register either by letter or resume if you are interested in openings listed in society journals. If you take a job as a result, a 4% placement fee is required. Often, the hiring company will pay all or part of it. Available, too, from ESPS, is a weekly bulletin of job openings that costs $4.50/-quarter.

Dim Outlook for Meeting Service

Despite these services, respondents to the CHEMICAL ENGINEERING survey overwhelmingly favored AIChE-sponsored employment centers at meetings. AIChE-member respondents, who would have most to gain from such an arrangement, and ACS-member respondents, who have already seen such an operation in their society-run clearing house, clearly believe there is a need. Whether there is or not is arguable.

Those who argue for a meeting marketplace defend a stand now taken by New York recruitment firm Deutsch & Shea. Originally proposing to society executives a one-year ban on all recruiting activity, the firm has since come to believe that society-sponsored employment centers, similar to the ACS clearing house, might be easier to run and control. Advantages of such centers include convenience and speed for the job-hunter, and elimination of behind-the-scenes piracy (now, some say, tacitly encouraged by AIChE).

Sources close to Institute affairs point out, however, that running such a service is an expensive proposition—especially since only half of one percent of the membership is interested in finding a job at any given time. Too, only 25% of the membership attends national meetings each year.

The same sources, moreover, hold that company opposition is a major deterrent to action, that firms who support the Institute and also send engineers to its meetings won't condone a formal arrangement that lets competitors hire those same engineers away.

There's at least one other argument against the clearing house operation, and that's a pragmatic one. Of all ACS members replying to the survey, only half had used this ACS service at meetings. And of those who did, only one-fifth found it helpful in obtaining a job. (Five respondents had tried the Career Center service of New Yorker Bill Douglass, all without success.)

ABOUT YOU AND YOUR JOB

Industry

Chemical & petrochemical	33
Petroleum refining & coal products	14
Metallurgical & metal products	8
Plastic materials, et al.	7
Wood, pulp, paper & board	7
Engineering & construction	7
Other	49
TOTAL	125

Age Group

20–24	2
25–29	19
30–34	33
35–39	43
40–44	17
45–49	6
50–54	3
55–59	2

Years With Firm

1 year	19	10	9
2	18	11	2
3	11	12	2
4	10	13	1
5	12	14	4
6	13	15	1
7	9	>15	4
8	3	Unknown	3
9	4		

Years in Present Position

1 or less	33	7	4
2	29	8	1
3	20	9	0
4	11	10	4
5	15	>10	3
6	4	Unknown	1

Number of Previous Firms

0	17	6	1
1	35	7	3
2	35	8	1
3	18	11	1
4	7	12	2
5	3	Unknown	2

Society Affiliation

AIChE	93
ACS	52
Other	48
None	11

Highest Degree

B.S.	75
M.S.	37
Ph.D.	8
Other	5

ABOUT YOUR LAST JOB CHANGE

Most Frequently Mentioned Reasons

More responsibility or opportunity	38
Layoff	19
Change industry or function	15
More pay	9
Relocation	7
Unsatisfactory management	6
Other	10

Length of Time Out of Work

0	82	2 months	6
1 week	1	3	5
2	1	4	1
3	1	6	2
4	3	8	1
6	2	2 years	1
7	2		

Method of Change

Letter of application	20
Answered ad	19
Recruited	16
Agency	15
Personal approach	13
Placed ad	12
Through contact in firm	10
Other	7

Dollar-Cost of Change

$0	47
$1–249	7
$250–499	8
$500–999	4
$1,000–1,499	8
$1,500–1,999	6
$2,000–2,999	4
$3,000–20,000	3

Whichever argument is more rational, it appears that employment centers at national meetings are still a long way off. Even if members can show good cause for them, the centers would face stiff competition—both from those who feel it's none of AIChE's business, and those who have to figure out the finances without sacrificing other membership services.

Meanwhile, several suggestions from respondents to the survey deserve study. One asked that a list of companies employing chemical engineers be kept by area or state. Such a listing might be supplemented by maintaining the current job openings on this geographic basis. Because location or relocation is a big factor to many in choosing a job, and because the basic data are now on hand at AIChE headquarters, such a service might be both useful and feasible.

A second suggestion would be operative at local-section level. In a way, it supplements the previous one. Calling for better feedback on jobs available, this respondent suggests that after a member has been interviewed for a job listed in local-section files, he should submit to the section a brief resume—perhaps by postcard—of his impressions of the position. Other job-seekers might then waste less time on interviews for jobs they didn't really want.

Finally, local sections, if they choose, can go a long way toward improving service by maintaining a two-way exchange of information between the AIChE headquarters staff man, James Buchanan, and the section. Though some already do, many others could improve these services within the framework of present policy by active employment coordination.

There is no question but that job mobility is of continuing concern to the employed engineer. Said an AIChE-member respondent: "[It] is the major bargaining point for engineers. The society should do all it can to straighten and police this area, in the interest of its membership." Said another member, more ominously, "The organized recruitment ban [suggested by Deutsch & Shea] is the sort of thing that may force engineers to organize unions in self-defense."

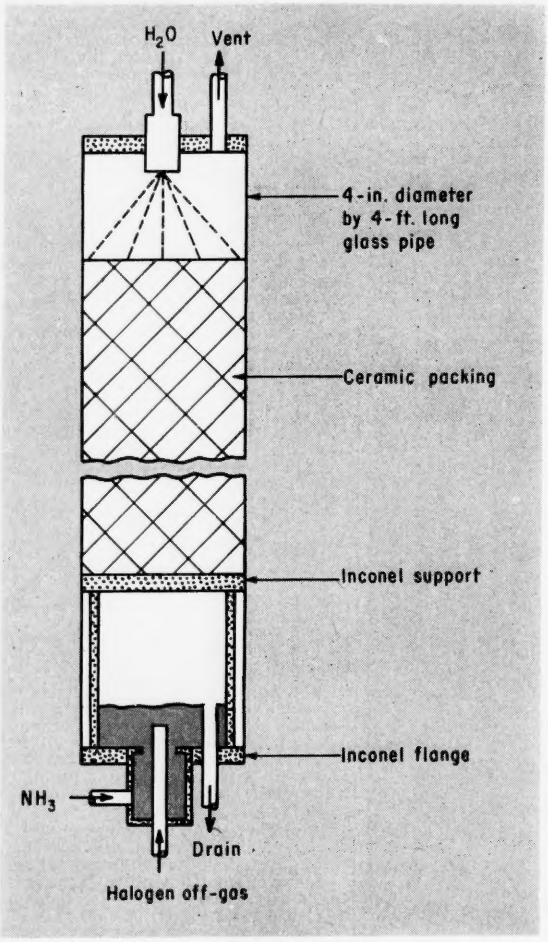
Whatever your views as to the need for employment services, you should acquaint yourself with what is now available. Some of these have been outlined here. Other tips will be found in earlier issues of CHEMICAL ENGINEERING (e. g., Feb. 20, 1961, p. 158; Dec. 15, 1958, p. 184). If you are looking for a new job, don't let your ignorance of well-established channels make *you* the biggest roadblock to that job!

VERSATILE SCRUB TOWER REMOVES HALOGEN OFF-GASES

Off-gases react with anhydrous ammonia gas to form ammonium-halide smoke, which is dissolved and removed by water spray.

Winner of the October Contest*

JOHN HOLMES, *Argonne National Laboratory*



COMING JANUARY 22

A High-Precision Level Indicator

J .O. Osburn and D. L. Allen, November Contest Winners

A simple, versatile and very efficient scrub system can be constructed for the disposal of halogen or halogen-acid off-gases from small-scale pilot plants. Often these toxic and corrosive gas streams are treated in bulky and sometimes inadequate caustic scrub systems, or are released directly to the atmosphere.

The scrub system shown in the illustration has been used for the disposal of chlorine, hydrogen chloride, hydrogen fluoride and mixtures of these gases. The halogen gases react with anhydrous ammonia gas in the space below the column packing, to form a smoke of ammonium halide. Water sprayed into the top of the column dissolves the solid ammonium halide from the column walls and packing. The dual gas-inlet nozzle, which is made of Teflon, is submerged under about 1 in. of scrub solution and is, therefore, self-cleaning.

An excess of ammonia (10—25%) is used with both chlorine and hydrogen fluoride to give an ammoniacal liquid waste and thereby reduce liquid-phase corrosion. Low hydrogen-chloride flows can be scrubbed by water alone, but much higher capacity and efficiency are attained by using ammonia reactant as well.

We have also investigated the fluorine-ammonia reaction and found it to be effective for removing fluorine from the off-gas stream. But, along with soluble ammonium fluoride, highly toxic and inert nitrogen trifluoride gas is produced and presents a secondary disposal problem. We have not tested the unit with gaseous iodine, bromine or their respective acids, but such operation should be routine.

Maximum flow rates are dependent on the solubility of the ammonium halides and on the flooding characteristics of the tower. The following rates are typical but not maximum for the tower dimensions:

Water	5–10 gal./hr.
HF	10 g.-mole/hr.
Cl_2	12 g.-mole/hr.
HF-Cl_2	20 g.-mole/hr.
HCl	15 g.-mole/hr.

This equipment has a much higher capacity and efficiency than the same size apparatus employing only gas-liquid caustic scrubbing because the gas-phase reaction is not limited by the usual adsorption liquid-phase-reaction mechanism.

Analysis of the off-gas from the scrub tower has shown efficiency to be nearly 100% in all tests. The fact that hydrogen fluoride does not etch the glass pipe if a slight excess of ammonia is used proves that the gas-phase reaction is highly efficient.

This work was performed under the auspices of the U. S. Atomic Energy Commission.

(Plant Notebook continues on page 96)

***How Readers Can Win**

$50 Prize for a Good Idea—Until further notice, the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for publication in the Plant Notebook. Each period's winner will be announced in the second following issue and published in the fourth following.

$100 Annual Prize—At the end of each year, the period winners will be rejudged by the editors and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant Noebook Editor, *Chemical Engineering*, 330 W. 42 St., New York 36.

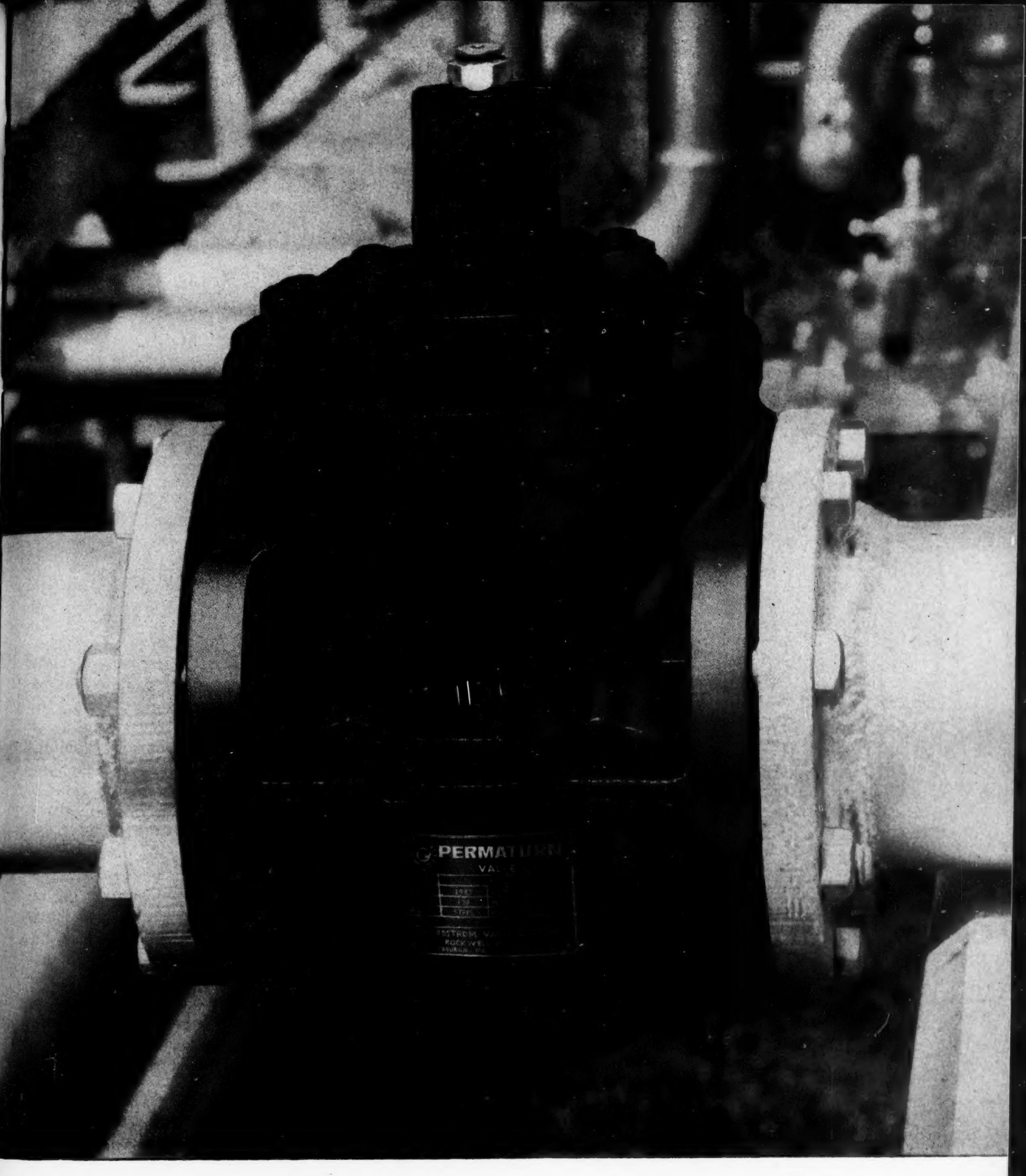

PERMATURN

TABLE CALCULATES CHANGE OF CONCENTRATION VS. TIME

FRANK LERMAN
U. S. Industrial Chemicals Co., Cincinnati

It is sometimes necessary to find the change in concentration of a liquid in a well-mixed vessel when there is continuous inflow of liquid at different concentration from that originally in the vessel.

By use of this table, one can readily calculate the time required for a continuous inflow of a stream of fixed concentration to change vessel concentration. Conversely, the concentration in the vessel can be found after a given inflow time.

The necessary assumptions are: (a) steady continuous inflow and outflow, (b) instantaneous perfect mixing, and (c) constant inflow concentration.

The definitions are: $\%C$ = percent change from original vessel concentration toward inflow concentration; P = number of holdup time periods to effect the change; H, holdup time, = vessel volume divided by inflow rate.

$\%C$	P	$\%C$	P	$\%C$	P
99	4.605	65	1.050	30	0.357
95	2.996	60	0.916	25	0.288
90	2.303	55	0.798	20	0.223
85	1.897	50	0.693	15	0.163
80	1.609	45	0.598	10	0.105
75	1.386	40	0.511	5	0.051
70	1.204	35	0.431	1	0.010

▶**Example**—The concentration of a component in a well-agitated, liquid-filled vessel of 48,000-gal. capacity is 0.40. At a steady continuous inflow and outflow of 6,000 gal./hr., how long will it take for the concentration in the vessel to reach 0.50, 0.60, 0.70? The inflow concentration is constant at 0.80.

The holdup time is calculated as 48,000/6,000 = 8 hr. The concentration 0.50 is a 25% change, 0.60 a 50% change and 0.70 a 75% change from the original vessel concentration toward the inflow concentration of 0.80.

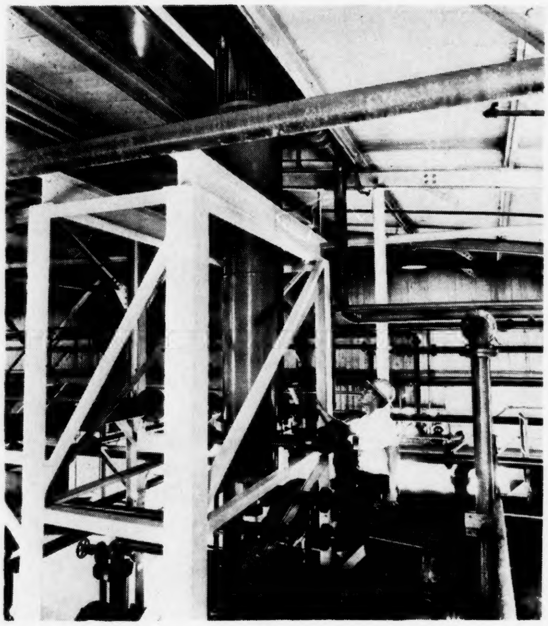
The number of holdup time periods for these changes are, from the table, 0.288, 0.693 and 1.386, respectively. Multiplying by 8 hr. gives time to attain 25% change (0.50 concentration) as 2.3 hr.; 50% change (0.60) as 5.5 hr.; 75% change (0.70) as 11.1 hr.

FALLING-FILM EXCHANGER ADAPTS TO ACID DILUTION

THOMAS M. GOLDMAN
Stauffer Chemical Co., Houston

We are sulfuric acid producers who find that we are doing more and more custom diluting for customers. Our previous manual batch system of mixing-off was the old method of measuring acid and water into a tank, and then pumping the dilute acid through cast-iron cooling coils. Because 78% acid was the most dilute that was produced, the coils held up well.

Increasing demand, including requests for 62% acid, led to the decision to install equipment flexible enough to handle a wide range of acid strengths on a semi-automatic basis. Our first thought was of a cascade cooler constructed of impervious graphite, a type being successfully used at one of our other plants. Discussions with National Carbon Co. engineers, however, led to the suggestion that we adapt the falling-film principle to diluting-cooling service.



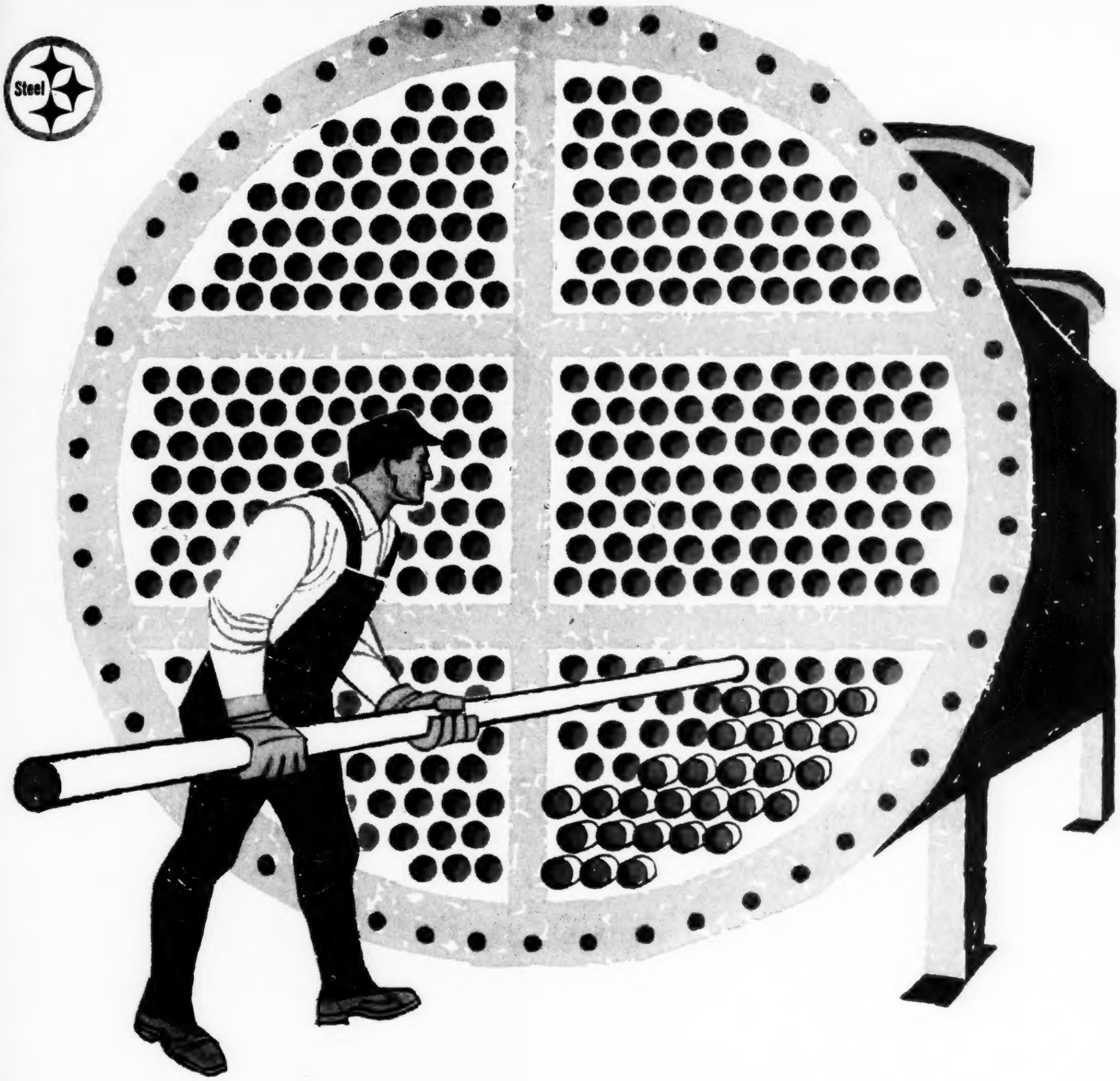
Falling-film device fits in small space over mixing tanks.

The expected advantage was elimination of feed-back of weak acid, without the need for valves. A special mixer dome had been developed for a falling-film exchanger that would assure complete mixing of separate streams of acid and water before the mixture got to the tubes. Accordingly, we purchased and installed the first such falling-film exchanger ever designed for diluting and cooling sulfuric.

A cascade unit would have required a floor area of approximately 10 x 38 ft., but the falling-film unit was installed in piggy-back fashion above our mixing tanks and uses no floor space. To achieve the desired flexibility, pipes were installed from five sources of acid supply as well as into four alternate product-storage tanks. For a simple installation, however, we estimate that, exclusive of piping, installation cost would be approximately half that of a cascade cooler of identical capacity.

Simplicity accounts for much of this saving. No concrete basin is required, no sewerage system, no headers for cooling water. Operating savings accrue from the elimination of water loss due to splash and windage, with no algae buildup to foul the equipment. The unit is also rugged, being enclosed in a steel shell.

The advantage of a cascade cooler operating under pressure and needing no pump is offset if the falling-film unit is installed at the point of use, with gravity



flow eliminating pumping of the process streams.

The unit was designed to handle 200 tons/day (100% acid), diluting from 99% to 65%. In actual practice, it dilutes to 62% acid and every strength above that.

Acid enters at 100 F., the diluting water at 80 F., and cooling water at 90 F. and 330 gpm. Exit-acid design temperature is 130 F. Rotameter controls at ground level near the diluter-cooler regulate incoming flow rates of both acid and water. A pressure regulator has been installed in the water line, and one is under consideration for the acid line.

The unit has 85 Karbate impervious graphite tubes, 1¼-in. O.D., ⅞-in. I.D. and 9-ft. long, for a total heat-transfer surface of 250 sq. ft. The tube bundle is enclosed in a 17¼-in. I.D. steel shell.

Since installation, the unit has operated almost daily without difficulty. Any overloading simply results in a higher exit temperature. A small dilute acid level is carried at the bottom of the tubes to facilitate temperature checks and sampling.

From 99% acid, we have produced 93.2, 90, 87, 78 and 62% sulfuric, and from 93.2% have produced all strengths below that. The graphite tubes handle both strong and weak acid equally well, making the unit particularly suited to our application.

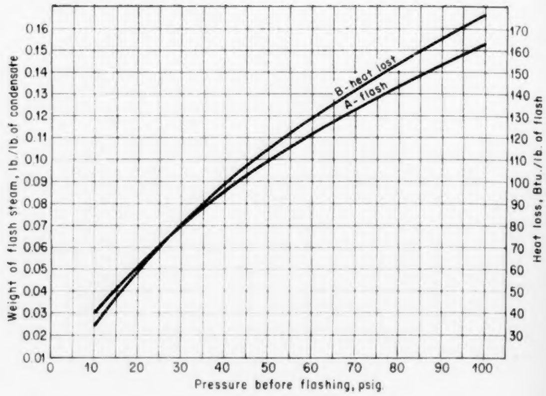
ON INCREASING ACCURACY OF PLANIMETER MEASUREMENTS

SURENDRA NATH SRIVASTAVA
Allahabad University, Allahabad, India

Measurement of the area bounded by a curve is frequently done with a planimeter. Sometimes, however, one finds that the instrument will not measure accurately enough for a specific problem. For example, assume that the planimeter has a least count of 0.01 sq. in. (6.3 sq. mm.), and it is desired to measure an area about 5 sq. mm. Clearly, the instrument is inadequate for the task.

We can overcome the difficulty by the same method that is used to measure the volume of one drop of water—measure the volume of 50 or 100 drops and divide by the appropriate number. With the planimeter, one can move the pin around the boundary ten times for a tenfold increase in accuracy. Theoretically, then, one can increase accuracy of measurement to any desired value.

A point of caution should be mentioned here, however, which limits this method. If one aims to increase accuracy 100 times or more, he will have to move the pin of the planimeter around the boundary 100 times or more. Besides being inconvenient, this procedure introduces an error in that in taking the pin around the boundary, one cannot follow it exactly. If the error is dA, then one cannot increase the accuracy beyond this figure. This sets a practical limit upon accuracy and limits also the number of rounds of the pin it is practical to take. In most cases, 10 or 20 times may be the optimum number.



FLASH STEAM DATA

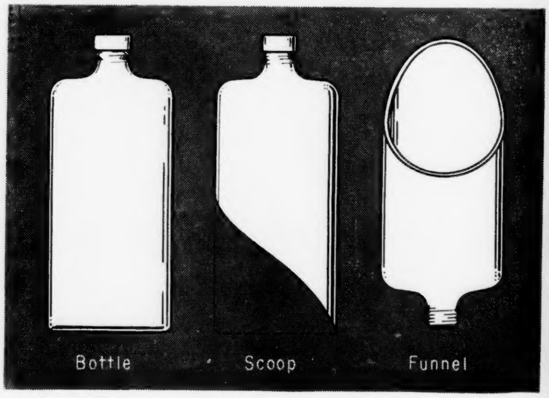
EDWARD J. GIBBONS
Colgate-Palmolive Co., Jersey City, N. J.

These two curves show: (A) flash steam formed per lb. of condensate (condensate collected at 1 atm. and 212 F.); (B) the heat lost in the flash steam. The curves are calculated from the following equations:

Flash steam, lb./lb. of condensate =

$$\frac{h_f - 180.07}{970.3} \times \frac{1}{1 - (h_f - 180.07)/970.3}$$

Heat lost, Btu./lb. = (flash, lb.) × 970.3 + (flash, lb.) × 180.07.



PE BOTTLE MAKES LAB SCOOP

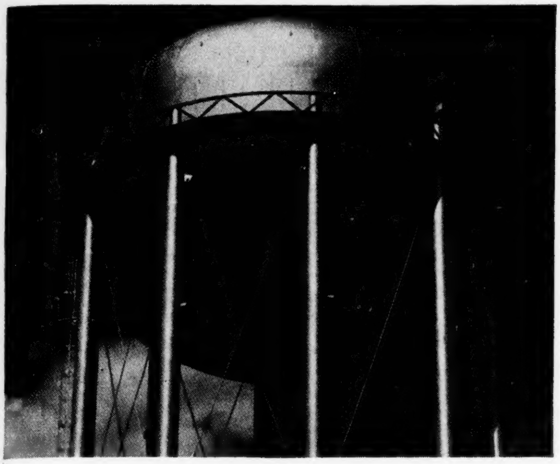
A. A. MACANKA
Metal and Thermit Corp., Rahway, N. J.

Recently our pilot plant found itself devoid of scoops used to charge small quantities of chemicals to reaction vessels. An emergency scoop, which served the purpose quite well, was made from a 1-qt. polyethylene bottle with a capped end. The scoop can also serve as a funnel if the cap is removed.

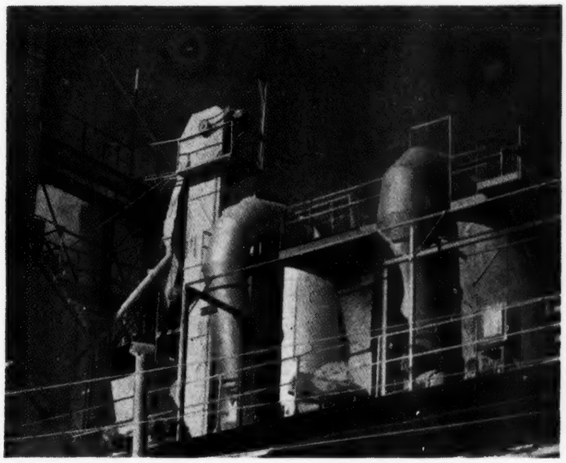
(Plant Notebook continues on page 100)

SILICONE NEWS from Dow Corning

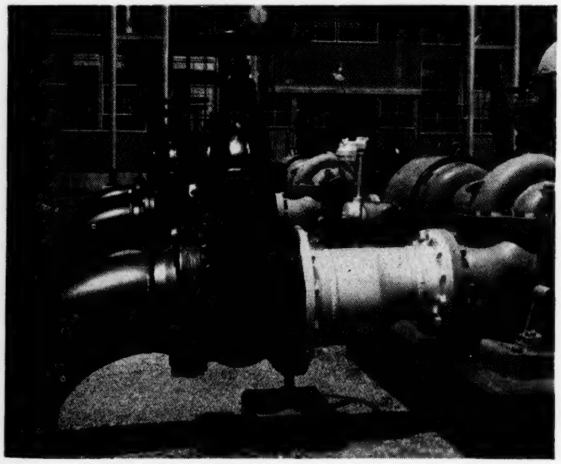
Sell silicone paint here



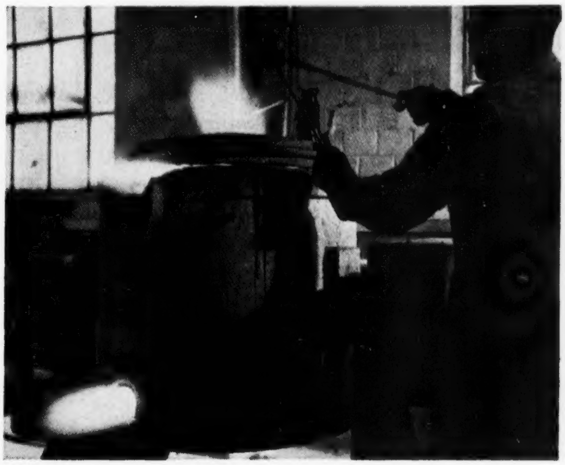
To resist weathering. Sun, sleet, smoke, rain ruined standard coatings within months on this water tower. But a silicone-alkyd paint is still on the job after two years; is expected to last for more years to come. Silicones helped make the sale; will help sell your paint, too. And you can cook your own vehicles with Dow Corning intermediates.



To resist heat. Surface temperatures on these kilns and stacks reach 650 to 750 F, 24 hours a day. Ordinary paints cracked, failed quickly. But a paint based on Dow Corning silicone resins has survived; prevented corrosion, saved money. Silicones helped make the sale; will help sell your paint, too. Silicone resins for every finish are available from Dow Corning.



To resist discoloration. A chemical atmosphere stripped ordinary paints, left piping ripe for rust. Enter a silicone-based paint. Surfaces have stayed bright, protected for more than three years. Repainting costs are reduced. Silicones helped make the sale; will help sell your paint, too. Write Dow Corning for full information about silicone-organic copolymers.

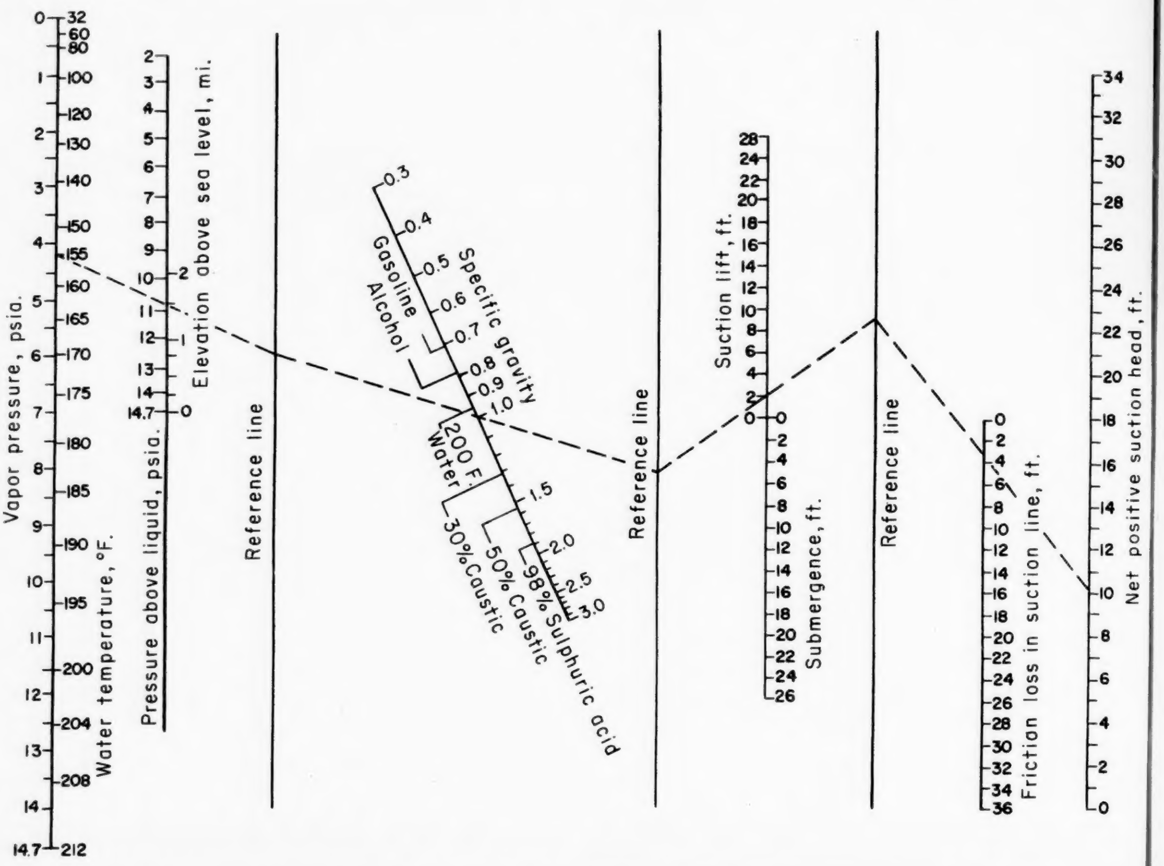


To resist corrosion. Even the best organic paints blistered, peeled within days on this bronze-melting furnace, running 10 hours a day at 650 F. But a paint based on Dow Corning silicone resins has lasted *seven years with no signs of failure.* Silicones helped make the sale; will help sell your paint, too. Dow Corning will help you with formulating and technical data.

Write Dow Corning Corporation for the complete story on the sales-building benefits silicones add to paints. Address Dept. 2424, Midland, Mich.

first in silicones

Dow Corning



NOMOGRAPH FINDS AVAILABLE NET POSITIVE SUCTION HEAD

ALAN STEVENSON
Worthington Corp., Harrison, N. J.

Proper design of a pump and piping system requires calculation of the system characteristics both at the suction and discharge ends of the pump. To avoid damage and assure good capacity with the utmost reliability, the suction side must be designed to provide adequate net positive suction head (NPSH).

This head depends on the vapor pressure of the liquid, lift or submergence of the pump, and friction losses in the suction piping. The discharge head is determined in similar manner, except that considerations other than the vapor pressure of the fluid enter into the calculation.

The nomograph provides a quick method of calculating net positive suction head from the known vapor pressure of the liquid, the atmospheric pressure (in an open system) and the suction-line pressure drop. It is based on the formula:

$$\frac{(P - P_v)\,2.31}{sp.gr.} - H_f \pm Z = \text{available NPSH}$$

where P = pressure above the liquid, psia.; P_v = vapor pressure of the liquid, psia.; $sp.gr.$ = specific gravity of the liquid; H_f = friction loss in the suction piping, ft.; Z = lift or submergence of the pump with respect to the level of the liquid, ft.; NPSH = net positive suction head, ft.

Lift or submergence Z is measured from the pump suction centerline or centerline of the impeller to the level of the liquid. For submergence, Z is positive—for a lift, Z is negative.

►**Example**—Find the NPSH available in a system with 4.2-psia. vapor pressure, 10.9-psia. pressure above the liquid, 1.0 specific gravity, 2-ft. suction lift and 3-ft. friction loss in the suction piping.

Following the dashed line from left to right on the nomograph shows that the answer is 10.5 ft.

This nomograph can also be used directly when water is being pumped at a known temperature and elevation above sea level.

FILM RELEASES CONCRETE FORMS

Recently, one of the construction people at Union Carbide Corp.'s Texas City plant came up with a novel use for polyethylene film. His idea was to line the inside of concrete forms with a sheet of the film, particularly those forms used in building foundations at the plant. In use, the forms practically fall off by

GAR-LINE PENTON TANK LININGS

for High-Temperature Corrosion Proofing

Can be applied to virtually any surface or contour to give superior, low cost protection against high-temperature corrosion. GAR-LINE Penton Tank Linings are replacing and out-performing more expensive materials in an ever-increasing number of applications.

Serviceable at temperatures up to 280°F, these efficient linings embody outstanding tensile strength, excellent dimensional stability and low water absorption. Chemically, they resist bleaching agents, solvents, plating solutions . . . in fact, all inorganic acids except fuming nitric and fuming sulfuric.

Applied by carefully selected and authorized applicators. The experience of these tank lining experts guarantees satisfactory GAR-LINE Penton installation, prevents expensive failure due to improper application. Approved applicators include:

ABRASION & CORROSION ENGRS.
1205 N. McMasters Street
Amarillo, Texas

ATTBAR PLASTICS
1107 Northeast 106th Street
Vancouver, Washington

BARTHEL CHEMICAL CONST. CO., INC.
P. O. Box 1025, Tacoma 1, Wash.

BITTNER INDUSTRIES, INC.
91 Diaz St., P. O. Box 10265
Prichard, Alabama

BUCKLEY IRON WORKS
21 Christopher St., Dorchester, Mass.

BUFFALO LINING & FABRICATING CORP.
73 Gillette Ave., Buffalo 14, N.Y.

CEILCOTE COMPANY, INC.
4832 Ridge Rd., Cleveland 9, Ohio

CHEMICAL PROOF OF SEATTLE
625 Alaska Ave., Seattle, Wash.

ELCHEM ENGRG. & MFG. LTD.
P. O. Box 249
Burlington, Ontario, Canada

ELECTRO CHEMICAL ENGRG. & MFG. CO.
750 Broad St., Emmaus, Penn.

THE FABRI-FORM COMPANY
P. O. Box 125, Byesville, Ohio

FLORIDA CORROSION CONTROL
P. O. Box 10082, Jacksonville 7, Fla.

THE FORTUNE COMPANY
1100 W. 37th St.—North
Wichita 14, Kansas

GALIGHER COMPANY
545 West 8th–S., Salt Lake City, Utah

GATES RUBBER COMPANY
Denver, Colorado

GOLDEN PLASTICS CORP.
333 East 8th St., Oakland 6, Calif.

GOODALL RUBBER COMPANY
2050 N. Hawthorne Avenue
Melrose Park, Illinois

HANSZEN PLASTICS COMPANY
835 S. Good-Latimer Exprw.
Dallas, Texas

HEIL PROCESS EQUIPMENT CORP.
12901 Elmwood Ave., Cleveland 11, O.

HUNTINGTON RUBBER MILLS of Port Coquitlam
B.C., Canada

INNER-TANK LINING CORP.
4777 Eastern Ave., Cincinnati 26, O.

MAURICE A. KNIGHT
Kelly Ave., Akron 9, Ohio

MERCER RUBBER CORPORATION
Highway 46, Cor. Huyler
Little Ferry, New Jersey

METALWELD, INC.
Scotts Lane & Abbottsford Rd.
Philadelphia 29, Pennsylvania

PARKER BROTHERS, INC.
7044 Bandini Blvd.
Los Angeles 22, California

PLASTIC APPLICATORS, INC.
7020 Katy Road, P. O. Box 7631
Houston 7, Texas

PROTECTIVE COATINGS
1602 Birchwood Ave., Ft. Wayne, Ind.

ROANOKE BELTING & RUBBER CO.
P. O. Box 1593, 345 Center Ave., N.W.
Roanoke 7, Virginia

RUBBER ENGINEERING & MFG. CO.
P. O. Box 2335, Salt Lake City 10, Utah

RUBBER MILLERS, INC.
707 S. Caton Ave., Baltimore, Md.

ST. LOUIS METALLIZING CO.
625 S. Sarah St., St. Louis 10, Mo.

L. H. SHINGLE CO.
1300 Walnut St., Camden 3, N.J.

STEBBINS ENGRG. & MFG. CO.
Watertown, New York

WILLOW RUN RUBBER COMPANY
12575 Haggerty St., Bellville, Mich.

Tailored to your specific needs, GAR-LINE* Penton** Linings can be applied to a variety of complex shapes as shown in these photos.

Investigate GAR-LINE Penton Tank Linings as the answer to your corrosion problems. For more information, contact the applicator nearest to you. Or, write for data on Penton; information also available on Teflon† linings for Anti-Stick or corrosive applications. Special Products Dept., Garlock Inc., P. O. Box 612, Camden 1, New Jersey.

*Garlock Registered Trademark
**Registered Trademark, Hercules Powder Company
†Registered Trademark, The DuPont Company

GARLOCK

themselves because they don't adhere to the concrete when the plastic film is in place.

Also, the finish on the concrete turns out much smoother than it would be with just a bare form. The forms can be used over and over, and the polyethylene holds in moisture so that the concrete will set properly. The smooth finish is also advantageous in cleaning equipment foundations.

PHYSICAL PROPERTIES OF ALLYL ALCOHOL SUMMARIZED

EDWARD M. BRAUN
Middletown, Ohio

Because allyl alcohol ($CH_2 = CH - CH_2OH$ or C_3H_6O) is now produced in commercial quantities for use in the resin, pharmaceutical and other industries, a compact tabular and graphical summary of its properties will be useful.

Boiling point (1 atm.)[1]	96.9 C.
Coefficient of expansion (20 C.)[6]	1.01×10^{-3}/°C.
Critical temperature[5]	271.9 C., 545 K. 521.4 F., 981 R.
Freezing point[1]	Indefinite, forms glass at −190 C.
Heat of combustion[3]	7,620 cal./g.
Latent heat of vaporization[8] at boiling point	163.4 cal./g. or 294.1 Btu./lb.
Mean specific heat of liquid, 20–90 C.[10]	0.665 cal./g. °C. or Btu./lb. °F.
Molecular weight	58.08
Refractive index, n_D^{25}, at 25 C.	1.4111
Specific heat of vapor	$c_p = 0.311 + 0.000745T$ where T is °K.

Vapor pressure (mm. Hg): temperature (°C.) relationship[1]

$$0\text{–}60\text{ C.}: \log p = 8.2946 - 1{,}764.4/(t + 230)$$
$$60\text{–}120\text{ C.}: \log p = 8.0986 - 1{,}707.4/(t + 230)$$
$$dp/dt \text{ at boiling point} \qquad 27.96 \text{ mm./°C.}$$

An aqueous solution containing 72.3% allyl alcohol by weight constitutes a constant-boiling mixture at 88.9 C. and 1 atm. pressure.

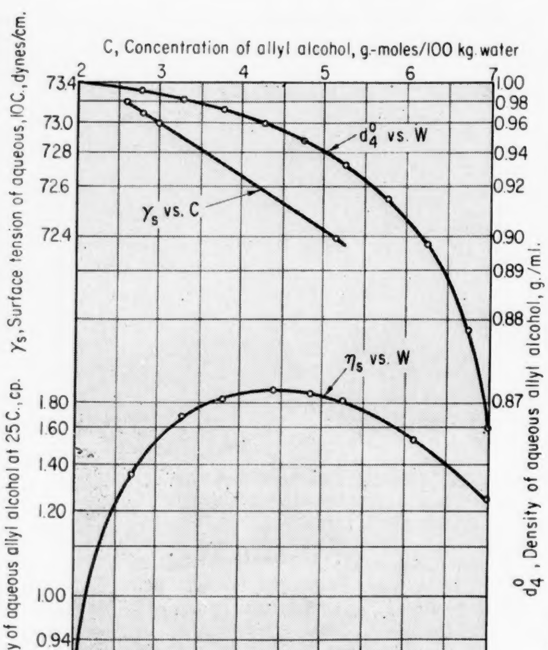
The charts show that, at 25 C., allyl alcohol has a density of 0.8476 g./ml., a viscosity of 1.20 cp.,[9, 10] a vapor pressure of 23.8 mm. Hg[1] and a surface tension of 25.22 dynes/cm.[6]

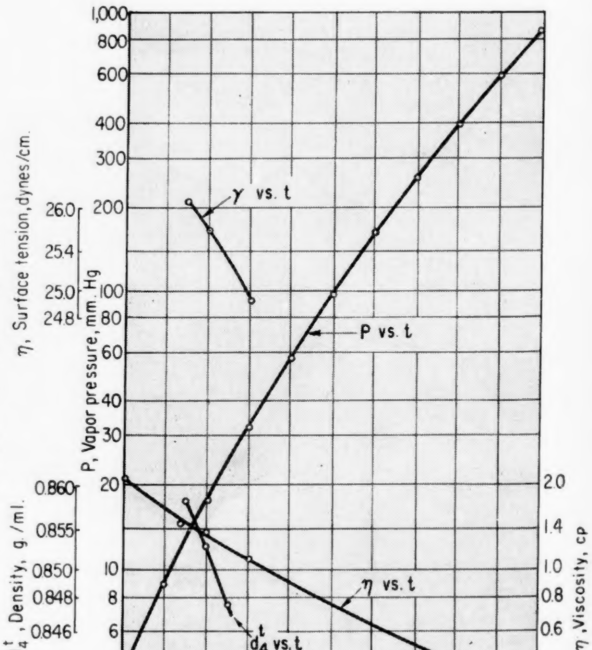
At 25 C., the viscosity of an aqueous solution that contains 30% allyl alcohol by weight is 1.74 cp.[2] At 0 C., an aqueous solution of the same composition exhibits a density of 0.980 g./ml.[6, 7]

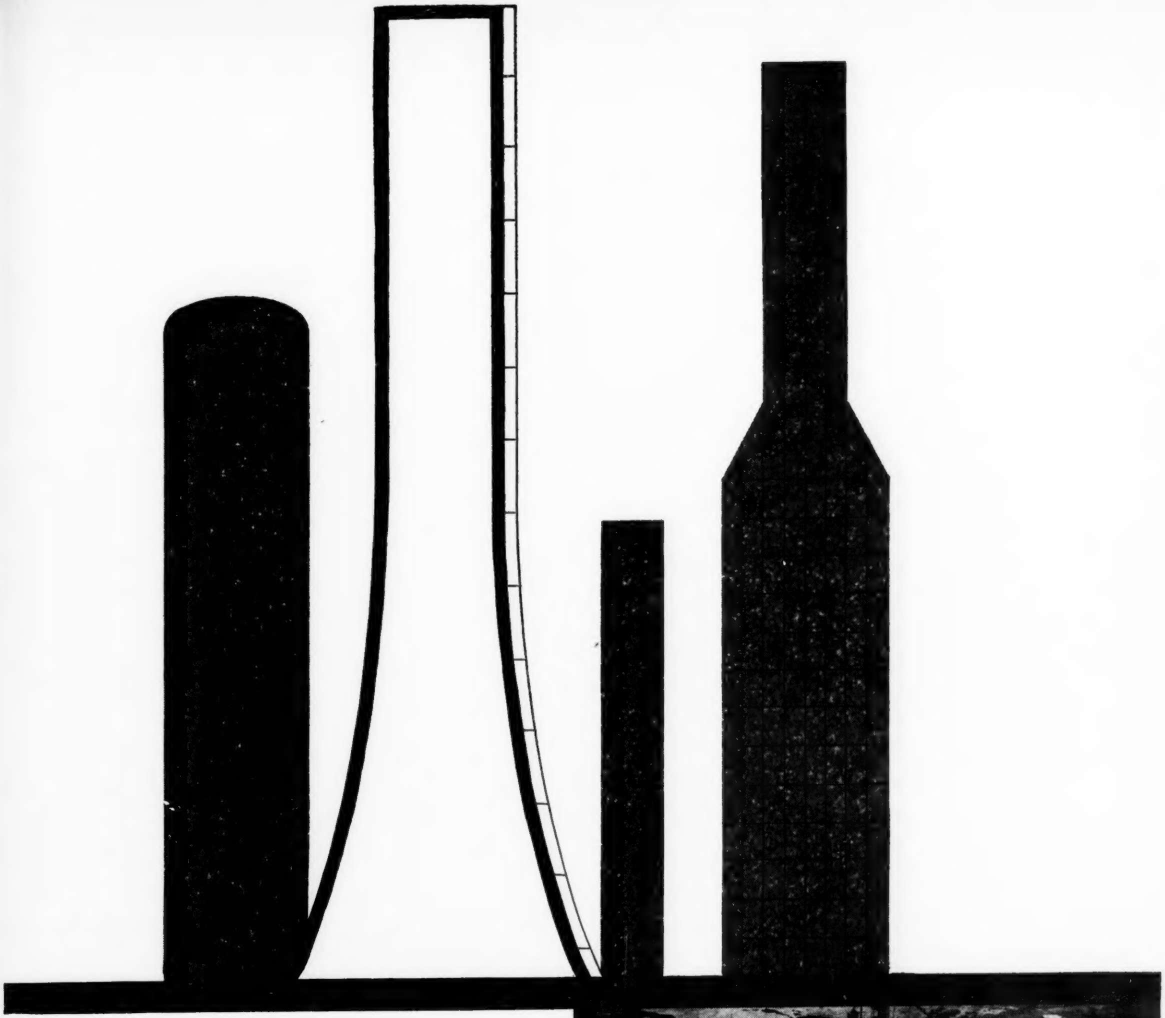
At 10 C., the surface tension of an aqueous solution that contains 3 gram moles of allyl alcohol per 100 kg. of water is 73 dynes/cm.[4]

References

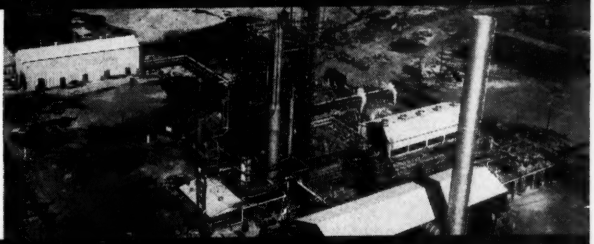
1. Dolliver, M. A., Gresham, T. L., Kistiakowsky, G. B., Smith, E. A. and Vaughan, W. E., *J. Am. Chem. Soc.*, **60**, 440 (1938).
2. Dunstan, A. E., *J. Chem. Soc.*, T, 11 (1905).
3. Kharasch, M. S., *Bur. Std. J. Res.*, **2**, 359 (1929).
4. Mills, H., Robinson, P. L., *J. Chem. Soc.*, 1629 (1931).
5. Nadejdine, A., *J. Russ. Phys. Chem. Soc.*, **14**, 538 (1882).
6. Timmermans, J., Hennault-Roland, Mme., *J. Chim. Phys.*, **29**, 529 (1932).
7. Wallace, T. A., Atkins, R. G., *J. Chem. Soc.*, 1179 (1912).
8. International Critical Tables, **5** (1925).
9. Landolt-Bornstein Tabellen.
10. Lange, N. A. (ed.), "Handbook of Chemistry," 7th ed. 1,621, Handbook Publishers Inc. (1949).







FOAMGLAS® Insulation works for GULF



EVIDENCE: Ten years ago, Gulf Oil Corporation selected FOAMGLAS Insulation for equipment at the Port Arthur, Texas, refinery. The insulation selection was important because of the high humidity in the area. The closed cellular glass structure of FOAMGLAS results in no water absorption, so GULF benefits from the same constant insulation value today as when FOAMGLAS was first installed.

Whether protecting short piping runs, tall ethylene towers or huge Hortonspheroids, FOAMGLAS Insulation insures corrosion-free operation because it stays impervious to water, vapor and acids. Because rigid FOAMGLAS can be easily cut to precise shapes, improper fitting is eliminated. And once FOAMGLAS is on the job, maintenance is kept to a minimum.

See how FOAMGLAS can solve your most severe insulation problem. Write for the Industrial Insulation Catalog: Pittsburgh Corning Corporation, Dept. CH-121, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Boulevard, Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS Insulation. Write for Data Sheets.

PITTSBURGH CORNING

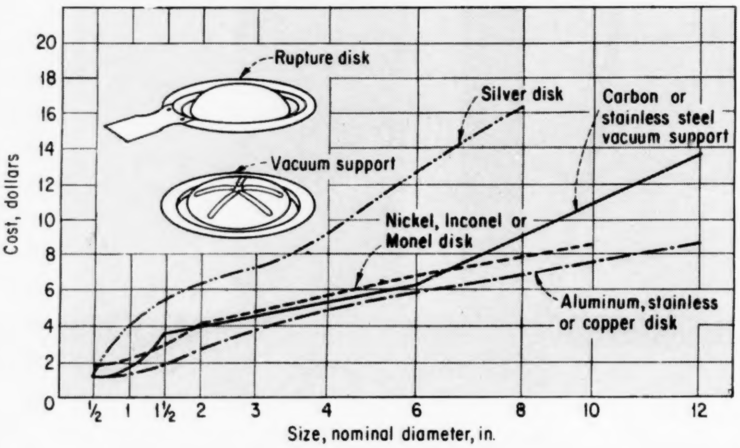
No. 60: Process-Vessel Protectors

Here are costs of rupture disks, flame arrestors, vent units and dehydrators—important equipment for protecting process vessels.

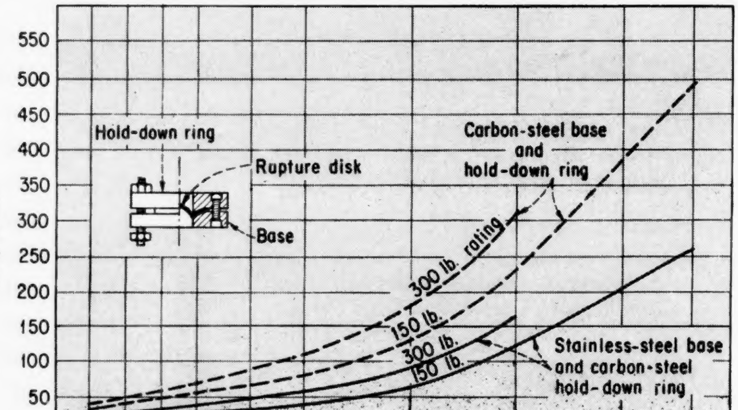
BELA G. LIPTAK
Instrument Engineer
Crawford & Russell, Inc.
Stamford, Conn.

There are a large number of devices used in the chemical process industries that fit into the category of "vessel protectors." We have collected purchase-price data on four such devices: rupture disks, flame arrestors, conservation vent units and dehydrators for storage tanks.

Rupture disks and vacuum supports—Fig. 1



Costs for base and hold-down flanges—Fig. 2



Rupture disks are very important and widely applied safety units used on vessels and other operating equipment for pressure relief. These disks act as weak spots in a vent line. At a preset pressure, this weak spot will rupture before the vessel becomes dangerously overstressed (see *Chem. Eng.*, Sept. 18, 1961, p. 187). Costs of such disks are shown in Fig. 1. Usually, the disk requires vacuum support if the pressure vessel operates under vacuum. Preformed, and fitted underneath the actual disk, a vacuum support prevents disk collapse from the force of atmospheric pressure.

In many cases, metal disks are firmly gripped between a base and hold-down flanges. Costs are shown in Fig. 2.

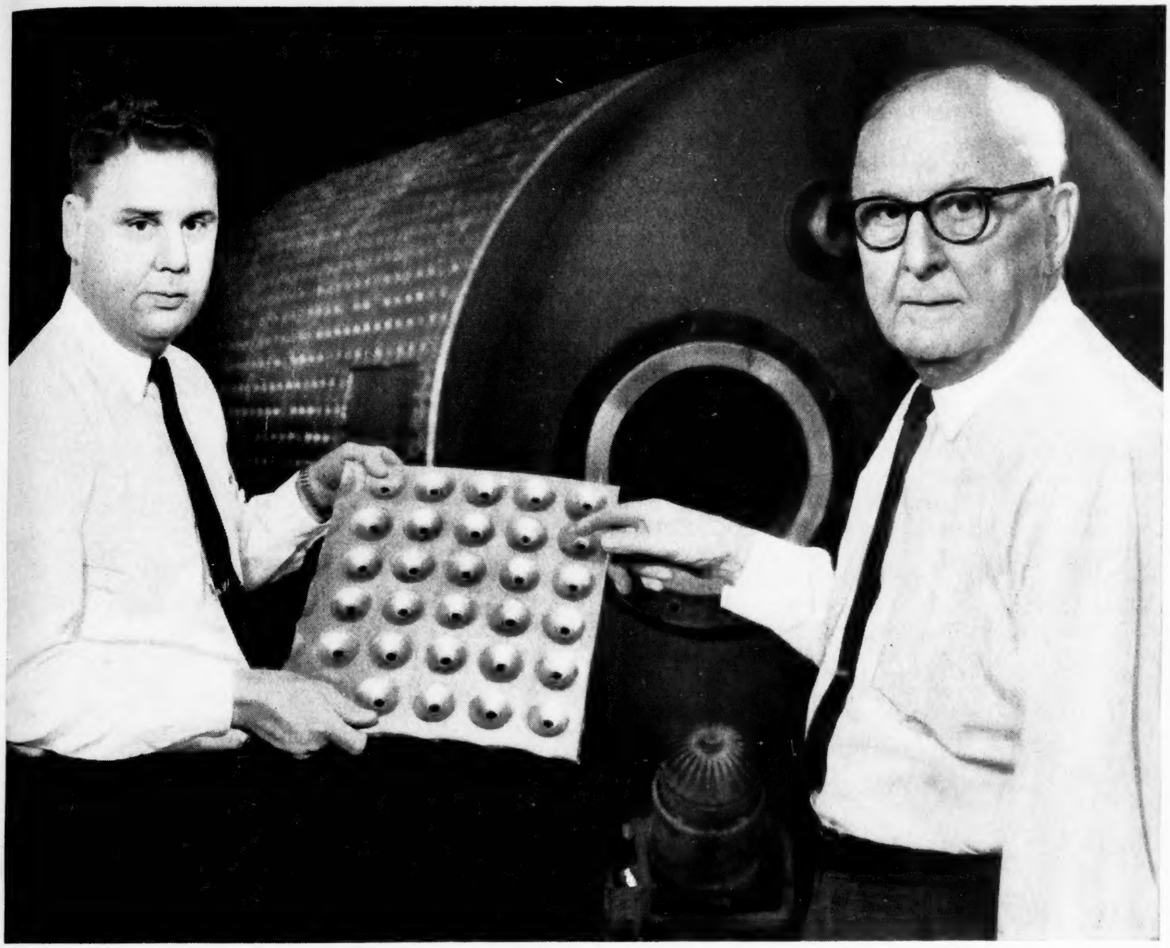
Graphite disks, shown in Fig. 3, are used at low preset pressures and in corrosive service. Such disks are directly mounted between flanges and do not require a base and hold-down flanges.

Flame Arrestors, Dehydrators

Flame arrestors are used on tanks holding volatile and flammable liquids. Gases passing through the breather vents, if ignited, cannot flash back into the tank. Flame arrestors contain "banks" consisting of flat and corrugated sheets arranged alternately so there is a vertical passage through the arrestor. Banks are deep enough so there is no burning through to the tank contents. See Fig. 4 for cost data.

On outdoor installations, flame arrestors are furnished with weather

* For previous articles by the author, see Cost File 55, Aug. 7, 1961, p. 137 (control and relief valves) and Cost File 59, Nov. 27, 1961, p 140 (process-control instruments).



"This Dimple Jacket Construction saves customers plenty!"

Paul Hock, President, Alvin I. Hock, Board Chairman, Brighton Corporation

Why? Because it's costing them 20 to 30% less than they've been paying for conventional reactors and it does a better job. Where formerly heavy gauge stainless was used to form the jacket and thick plate for the tank liner, light gauge was substituted. To gain the same amount of resistance to pressure, the stainless steel was dimpled. The jacket was then formed and placed on the kettle by our special welding method. This method was evolved after extensive research by our metallurgists and at the present time, is a special process exclusive with Brighton. While the jacket is ASME approved to 162 p.s.i., exhaustive tests have shown it to withstand bursting pressures up to 1000 p.s.i.

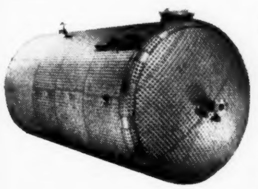
Write for Bulletin No.BF-6, or send your specifications for a prompt quotation to Dept. A-12.

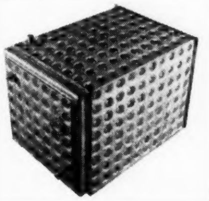
BRIGHTON CORPORATION

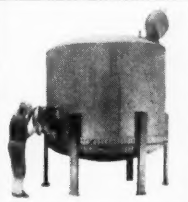
CINCINNATI 4, OHIO

Brighton Dimple Jacketed Tanks are built for these industries:

chemical	*pharmaceutical*
petrochemical	*paint and varnish*
petroleum	*distilling and wine making*
explosives	*paper and paperboard*
beverage	*food processing*







hoods (see Fig. 4). The opening on the hood has a mesh wire screen to prevent large, wind-blown, particles from getting into the flame arrestor.

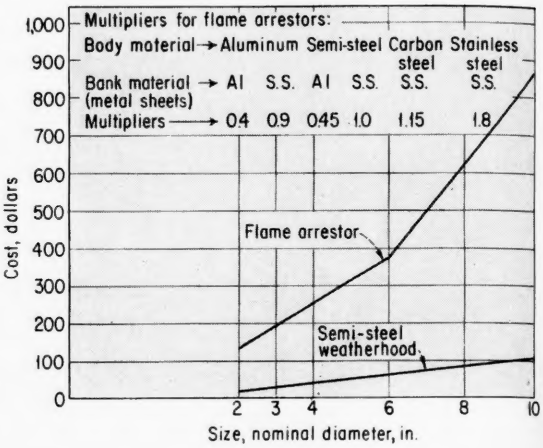
As an example of how to use Fig. 4: What is cost of 3-in. flanged flame arrestor, carbon-steel body, stainless-steel bank material, semi-steel weatherhood? From curve, arrestor is $195; multiplier is 1.15, weatherhood is $25. Total is $250.

Conservation vent units (Fig. 5) control tank breathing. They prevent free escape of vapors and also protect the tank contents from the possibility of fire entering the tank through a vent pipe.

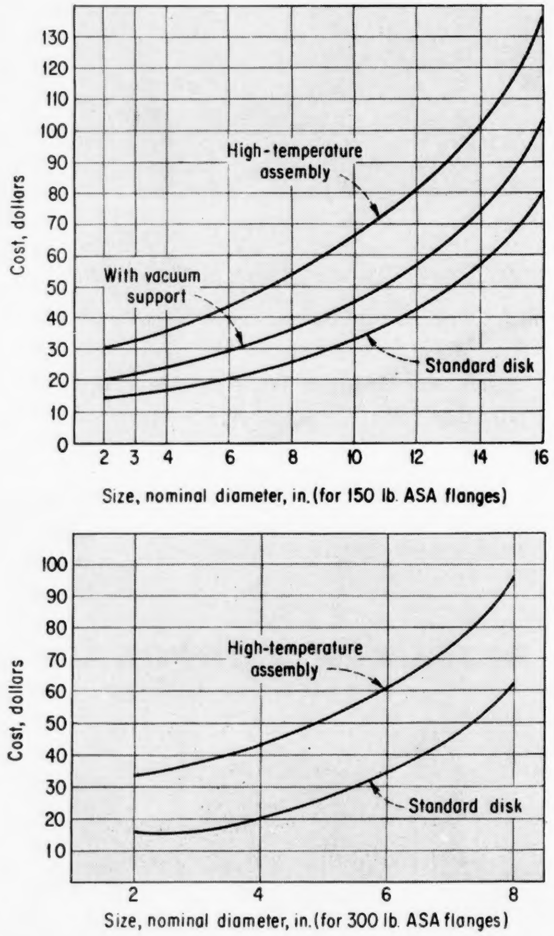
Dehydrators (Fig. 6) remove moisture from any air entering storage tanks. They are particularly useful when a product is being removed from a tank—wet air coming in through a vent line during this operation could dilute or contaminate the tank contents. The unit on which the cost data of Fig. 6 are based consists of a bed of activated alumina, held in a wire basket; all in a gas-tight housing.

Costs refer to first-quarter, 1961.

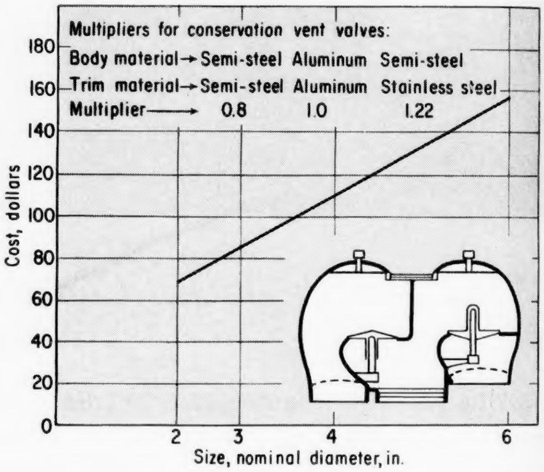
Flanged flame arrestors—Fig. 4



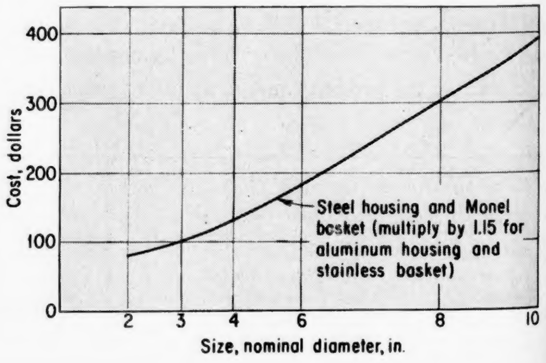
Graphite disks for corrosive service—Fig. 3



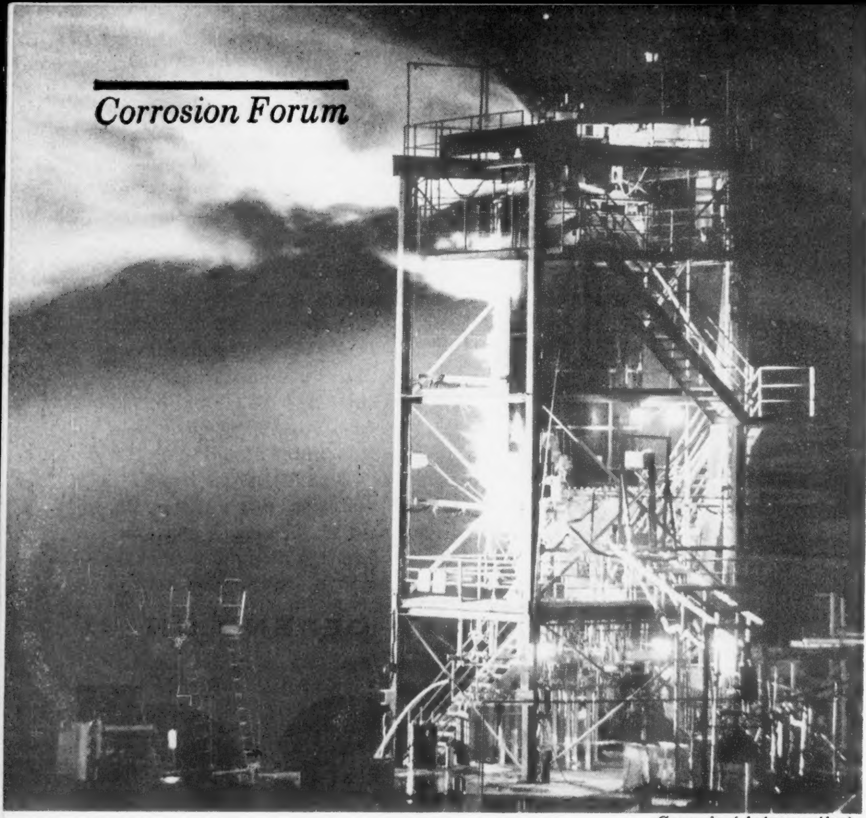
Conservation vent units—Fig. 5



Costs of dehydrators—Fig. 6



Corrosion Forum



Convair (Astronautics)

Steel Tanks For Rocket Fuels

Here's basic information on using precipitation-hardening stainless steels to hold exotic fuels and oxidizers.

JOHN HALBIG, *Armco Steel Corp.*

Precipitation-hardening stainless steels offer a combination of corrosion resistance and high strength, over a wide temperature range, that is becoming increasingly attractive to engineers designing rocket-propellant holding and handling devices.

During initial materials-selection work, the specifics of corrosion resistance often assume paramount importance when rocket fuels and oxidizers are involved.

The following discussion presents pertinent liquid rocket-propellant corrosion data for 17-4 PH, 17-7 PH and PH 15-7Mo stainless steels. Armco 17-4 PH and 17-7 PH were the first of the precipitation-hardening stainless steels and were closely followed by PH 15-7Mo. These materials have been widely used in missile, aircraft and industrial applications.

However, information in the specialized area of rocket-fuel corrosion rates has not been readily available from one source, although information on mechanical properties and data on corrosion resistance in common media have been readily available for some time.[1-4] Most data reported here have been developed by propellant producers or by other research agencies.

A particularly well-known source that has been utilized is DMIC (Defense Metals Information Center) Memorandum No. 65, prepared by Battelle Memorial Institute.

The steels covered are 17-4 PH, 17-7 PH, PH 15-7Mo; the constituents of these steels are shown in the table on the next page.

Precipitation-hardening stainless steels are used for tanks, thrust chambers, fins, fuel-line elements, control shafts, and related components for various fuels and oxidizers. These include oxygen, hydrogen, nitrogen tetroxide, red and white fuming nitric acid, anhydrous ammonia, hydrogen peroxide, hydrazine and unsymmetrical dimethyl hydrazine (UDMH). Except for long-time retention of hydrogen peroxide, discussed later, these precipitation-hardening stainless steel alloys are suitable for storage as well as short-time usage.

In most chemical media, corrosion resistance of the above stainless steels will generally be equal to or somewhat lower than that of standard chromium-nickel grades. Corrosion resistance is considerably better than that of the standard hardenable grades. However, as in all types of corrosion, rates will be greatly affected by temperature, concentration of solutions, contaminants, surface conditions and other factors.

▶ **Hydrogen Peroxide** — With hydrogen peroxide, the major consideration is decomposition rate rather than possible corrosive effects on stainless steel. Surface contamination accelerates the rate of peroxide decomposition.

In one report (dated 11 years ago), it was stated that 17-4 PH (heat treatment not indicated) had a corrosion rate of 0.4 mils/yr. in 90% hydrogen peroxide, based on a 1-wk. test.[5] It is particularly interesting that no catalytic decomposition occurred during the first two days. Thereafter, a very slow

YOU DON'T HAVE TO REPLACE YOUR VALVES OVER AND OVER AGAIN

There is no point in buying a "good" valve and then paying to replace it over and over again. This kind of valve maintenance not only costs man hours; it costs even more in process down time. You can put a Durco SLEEVELINE® valve in your line and forget it.

Long service life. The large sealing area of the Teflon* sleeve will withstand erosion, nicks, scoring and general wear for years in process liquids, gases or slurries without leakage. Plugs and bodies are available in the right Durco alloys to withstand specific corrosive conditions. In fact, some of the first Sleeveline valves sold over ten years ago are still in service in many of these applications.

No lubrication. A Teflon sleeve surrounds the plug. Teflon's resiliency and low coefficient of friction seal tight, yet permit the plug to turn without backbreaking effort.

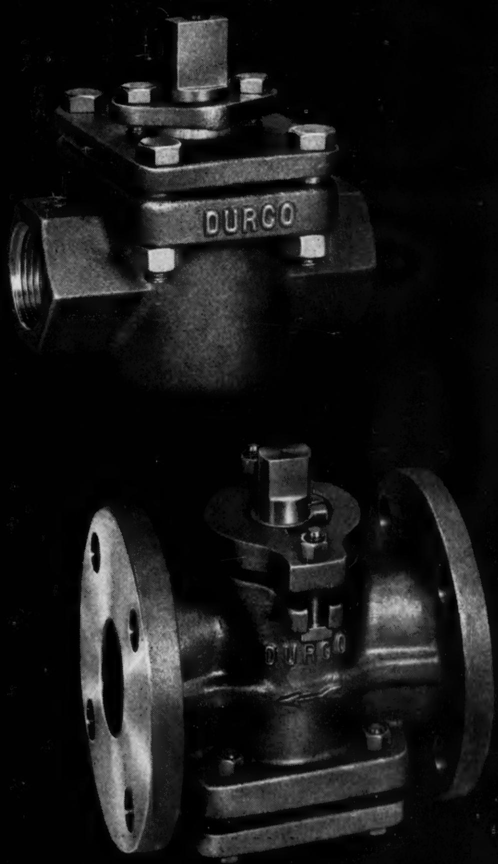
Simple adjustment for wear. The thickness of the Teflon sleeve allows for up to 1/4" of vertical adjustment for wear before sleeve replacement becomes necessary.

No machining or replacement parts. When wear or damage require replacement of a sleeve or plug there is absolutely no machining or fitting. No disc assemblies have to be reground or fitted, no plugs have to be lapped. New Durco plugs will seal in old sleeves—new Durco sleeves will seal around old plugs. There is complete interchangeability of new and old parts in any Durco valve of a given size.

* DU PONT REGISTERED TRADEMARK

DURCO

THE DURIRON COMPANY, INC.
DAYTON, OHIO
Serves the process industries



Chemical analyses of Armco precipitation—hardening stainless steels

	PH 15-7Mo	17-7 PH	17-4 PH
Carbon	0.09 Max.	0.09 Max.	0.07 Max.
Manganese	1.00 Max.	1.00 Max.	1.00 Max.
Phosphorus	0.04 Max.	0.04 Max.	0.04 Max.
Sulfur	0.04 Max.	0.04 Max.	0.03 Max.
Silicon	1.00 Max.	1.00 Max.	1.00 Max.
Chromium	14.00-16.00	16.00-18.00	15.50-17.50
Nickel	6.50-7.75	6.50-7.75	3.00-5.00
Molybdenum	2.00-3.00	——	——
Aluminum	0.75-1.50	0.75-1.50	——
Copper	——	——	3.00-5.00
Columbium and tantalum	——	——	0.15-0.45

evolution of bubbles began, but did not increase in intensity. No data are given on the temperature or the peroxide strength at the end of the week-long period.

There has been apprehension about the use of 17-4 PH in hydrogen peroxide because of the presence of copper in this alloy. This is not a valid objection, as the copper is not present in the alloy as free copper but is completely tied up with other alloying elements so that it will not affect the H_2O_2.

This is confirmed by the complete absence of attack on 17-4 PH after a 2,260-hr. test involving sodium acetylide sludge, which is highly corrosive to copper.

The Battelle work[6] provides more information on hydrogen peroxide and the precipitation-hardening types of stainless. Battelle uses several rating systems for materials in rocket-propellant service. One, for example, takes into account corrosion rate, decomposition and impact sensitivity.

Hydrogen peroxide is difficult to classify for construction materials. Decomposition effects are of primary concern and the rating system differs. In this and other sections that follow, the terms Class 1, 2, 3 or 4 do not necessarily mean the same thing. In each instance where such rating is given, its meaning in that instance is also given.

DMIC[6] places 17-7 PH of 37-45 Rockwell "C" hardness, and unhardened 17-7 PH, in the Class 2 category for 90% H_2O_2 service. This means that for this propellant the maximum active oxygen loss by the H_2O_2 in one week, at 30 C., is 6%; at 66 C., the maximum loss in one week is 80%. There is no other effect on the H_2O_2.

No corrosion of the 17-7 PH itself occurs, although a slight bronzing of the metal is considered permissible. Buffed 17-7 PH, Rockwell C45, is placed in this same category.

In Class 3, DMIC has placed electropolished and pickled 17-7 PH (Rockwell C45) and 17-4 PH (hardness not indicated). For Class 3 materials, the maximum active oxygen loss by H_2O_2 in one week at 30 C. is 11%; at 66 C., the maximum loss is 100% in 24 hr. Under this rating, bronzing and staining but no rust or other corrosive products are permitted. Slight attack is allowed, however.

In general, the 17-7 PH type of stainless steel is satisfactory, but the 400-series steels are not. A 120-grit finish on the 17-7 PH steel improves service.

One means of reducing decomposition is passivation. After cleaning with appropriate solvents and rinsing with tap water, the 17-7 PH steel is treated with a 2% $Na_2Cr_2O_7 \cdot 2H_2O$—20% HNO_3 solution for ½-hr. at 120-130 F., followed by conditioning in the concentration of H_2O_2 that the alloy will be required to handle.

A typical application of a precipitation-hardening stainless steel with the propellant is the use of 17-7 PH for valve stems in control valves for the *Freedom VII* capsule that lofted the first U. S. astronaut.

The only corrosion problem encountered in early tests was accelerated corrosion of a cast-aluminum valve body. (The proximity of the aluminum and the 17-7 PH actually benefited the stainless at the sacrifice of the aluminum casting.) The problem was solved by coating with Teflon that portion of the valve stem in contact with the aluminum.

▶**Ethylene Oxide**—17-4 PH, 17-7 PH and PH 15-7Mo do not promote polymerization of ethylene oxide. The maximum corrosion rate determined from weight loss after two weeks in commercial distilled ethylene oxide at 257 F. was 0.06 mils/yr. or less. 17-4 PH (condition H900) and 17-7 PH (conditions RH1005 and TH 1050) are more resistant to pitting in this medium than PH 15-7Mo and Type 304 stainless, but pitting can occur.

▶**Hydrazine**—In several processes for the manufacture of hydrazines, sodium hypochlorite and other chlorine-containing compounds are used. As a result, commercial hydrazines may have some chloride ions present. In appreciable amounts, these ions conceivably could lead to corrosion in the presence of water. This point should be recognized.

Hydrazine compatibility with various metals depends on the corrosion behavior of the material on the one hand and the effect of the material and corrosion products on the rate of hydrazine decomposition on the other.

DMIC[6], in its compatibility survey of various materials, lists 17-7 PH stainless steel in Class 3 for applications at 160 F. For Class 3 materials, corrosion rates of 5 to 50 mils/yr. are permitted. The material may cause moderate breakdown of the propellant, but it is not shock-sensitive under conditions likely to be found in service.

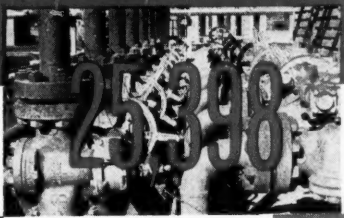
In general, stainless steels containing more than 0.5% by weight molybdenum and copper should be avoided, especially at temperatures above 100 F. Since 17-4 PH and PH 15-7Mo contain more copper or molybdenum than this, their use in this medium must be considered with caution. Testing under simulated operating conditions is indicated.

▶**Dimethyl Hydrazine** — The hydrazine derivative, unsymmetrical dimethyl hydrazine (UDMH), affects materials in much the same manner as hydrazine. Of the metals, low-alloy steels, aluminum, and

Why experiment? 221 million square feet of steel have already been protected by

DIMETCOTE®

This is equivalent to coating...



25,398 miles of 6 in. pipe . . . enough to encircle the earth.

The shells of 17,588 floating roof tanks (55,000 bbl.).

The weather decks of 5,973 T-2 tankers.

The hull exteriors of 3,252 T-2 tankers.

The cargo tanks of 701 T-2 tankers.

The decks of 28,333 floating roof tanks (55,000 bbl.).

When Dimetcote was introduced in the United States from Australia in 1950 the idea that a single coat of "paint" could resist weathering, salt spray, petroleum products and severe abrasion for 10 years seemed incredible. *Actually there are today many Dimetcote installations which have been in service for over 20 years without maintenance.*

The success of Dimetcote has literally forced a revolution in the paint industry. Most major paint manufacturers are working to develop "something like Dimetcote" to fill the breach. Some of these products may eventually approach Dimetcote's performance, but this will not be known for several years.

Short-term tests of inorganic zinc coatings are meaningless. Repeated Florida tests for weathering and sea water immersion (constant and intermittent) prove this. Some of the new zinc coatings perform well for 18 to 30 months, then suddenly break down completely, allowing general rusting and pitting of the underlying metal.

So don't be misled. All zinc coatings are not the same. Only Dimetcote gives you time-tested performance, not "long life" projections based on short-term tests. *Since Dimetcote costs no more per mil square foot than the unproven products . . . why experiment?*

Write for complete technical data:

Amercoat® CORPORATION

137

Dept. A-Y, 4809 Firestone Blvd., South Gate, Calif.

2404 Dennis Street Jacksonville, Florida	921 Pitner Avenue Evanston, Illinois	111 Colgate Avenue Buffalo 20, New York	360 Carnegie Avenue Kenilworth, New Jersey	6801 Silsbee Street Houston, Texas

stainless steels are commonly used to contain UDMH. Due to the greater stability of UDMH, DMIC[6] has placed 17-7 PH (hardness not stated) in Class I, the completely compatible category, up to 160 F. Derr and Raleigh[8] show rates of less than 0.1 mils/yr. for PH 15-7Mo and 17-7 PH (conditions not indicated) in 28 days at 86 F. and less than 0.1 mils/yr. for 17-7 PH at 146 F. for 7 days. No change was observed in the UDMH stability.

Derr and Raleigh,[8] in a discussion appended to their paper, concluded that UDMH was much less sensitive to decomposition by oxides of molybdenum and copper than hydrazine. As their tests were of very short duration (5 min.), they did not know what effect these oxides might have on UMDH decomposition after long-time exposure. They reported more-extensive tests, involving copper and molybdenum, were in progress.

▶ **Oxygen**—While oxygen is highly reactive chemically, liquid oxygen is noncorrosive to most metals. In particular, the precipitation-hardening stainless steels hold up well.

▶ **Ammonia**—All three grades of precipitation-hardening stainless steels—17-4 PH, 17-7 PH and PH 15-7 Mo—are considered satisfactory for handling ammonia. The 17-4 PH grade, containing some copper, is not adversely affected by cracking as are standard copper alloys. Generally, temperature limits for these steels in ammonia service are high. (The upper-temperature limit is actually the nitriding temperature.)

While air as a contaminant is believed to lead to cracking in high-strength nonstainless steel ammonia-storage tanks, no data are available on these precipitation-hardening alloys in this regard.

▶ **Hydrogen**—Liquid hydrogen and gaseous hydrogen at low temperatures are both considered to be noncorrosive.[6] Low-temperature embrittlement is more important.

▶ **Nitrogen Tetroxide**—In static tests with 3.2% by weight water from 3 to 27 days, PH 15-7 Mo (condition RH950) has shown very low corrosion rates up to 74 C. Under circulating conditions at 26 to 31 C. for 101 and 104 hr. of test, PH 15-7 Mo (condition RH950) has shown no corrosion.[9]

▶ **Fuming Nitric Acids**—The fuming nitric acids used in propelling systems are very corrosive to metals. Red fuming nitric acid (RFNA) may contain up to about 30% nitrogen dioxide and about 2-3% water. White fuming nitric acid (WFNA) may contain as much as 2% nitrogen dioxide and 2%, or less, water.[6, 10]

Neither red nor white fuming nitric acid has much in common with 65% boiling nitric acid.[10] The corrosion behaviors, in particular, are of a different magnitude.

Fontana[11] reports rates for austenitic stainless steels in white fuming nitric acid at 122 F., slightly lower than in the red acid. These rates vary between 12 to 70 mils/yr., depending on the type of stainless steel. At 160 F., the rate increased roughly four- to five-fold.

Other data indicated that 17-7 PH (condition TH 950) has a very low corrosion rate in WFNA, about 1 mil/yr. at room temperature, but a very high rate of about 300 mils/yr. at 160 F.

Also, 17-7 PH (condition TH 1050) is less resistant to the corrosive action of red fuming nitric acid than types 304 and 347,[12] corroding at a rate of 250 to 300 mils/yr. at 120 F. At 160 F., 17-7 PH corrodes at a still higher rate. (These rates are based on tests that ran 30 days or less.)

Phelps, Lee and Robinson[13] discuss in detail the effectiveness of hydrofluoric acid as an inhibitor of corrosion of 17-7 PH by red fuming nitric acid that contains 12% NO_2 at 120 and 160 F. The addition of 0.75% hydrofluoric acid reduced the 120 F. corrosion rate to 1.7 mils/yr. in the liquid phase and 0.16 mils/yr. in the vapor phase. Effective inhibition also occurred at 160 F. Thus, 17-7 PH is highly satisfactory when hydrofluoric acid can be used in red fuming nitric acid.

The Battelle DMIC report[6] places hardened 17-7 PH (aging treatment not indicated) in Class 2 at 130 F. for inhibited RFNA containing 0.6± 0.1% HF as the inhibitor. This class indicates that a corrosion rate as high as 5 mils/yr. is permitted, with no decomposition or impact sensitivity. Mason and his associates[14] found a marked reduction in corrosion of 17-7 PH (condition TH 1050) at 130 F. with an addition of about 0.5% by weight hydrofluoric acid in fuming nitric acid.

References

1. Marshall, M. W., others, *Metal Progress*, **70**, No. 1, 94-98 (1956).
2. Halbig, J., Ellis, O. B., *Corrosion*, **14**, No. 8, 389t-395t (1958).
3. Marshall, M. W., Tanczyn, H., *Metal Progress*, **75**, No. 3, 121-125 (1959).
4. Applications Bulletin, "Armco Precipitation Hardening Stainless Steels—Missile Applications," Armco Steel Corp., Dec. 1, 1960.
5. Huston, K. M., private communication, Apr. 4, 1950.
6. Boyd, W. K., White, E. L., DMIC Memorandum 65, "Comptability of Rocket Propellants with Materials of Construction," Battelle Memorial Institute, Sept. 15, 1960.
7. Huston, K. M., private communication, Dec. 30, 1958.
8. Raleigh, C. W., Derr, P. F., *Corrosion*, **16**, No. 10, 507t-511t (1960).
9. Alley, C. W., others, *Corrosion*, **17**, No. 10, 479t-484t (1961).
10. Clark, J. D., Walsh, M. E., Transactions of the New York Academy of Sciences, Series II, 17, No. 4, 279 (1955).
11. Fontana, M. G., Reports of the Ohio State University Research Foundation (1951).
12. Srp, O. O., private communication, Aug. 3, 1956.
13. Phelps, E. H., others, WADC Technical Report 55-109 (1955).
14. Mason, D. M., others, *Corrosion*, **13**, No. 12, 821t-827t (1957).

Meet the Author

JOHN HALBIG *is a senior research engineer engaged in corrosion work at the research center of Armco Steel Corp., in Middletown, Ohio.*

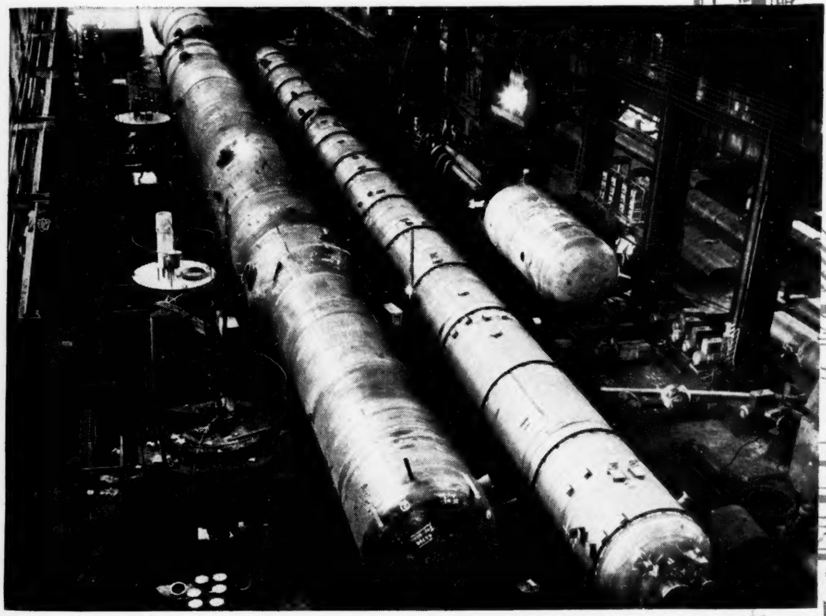
He has a B.E. in chemical engineering from Johns Hopkins University, and is a member of the National Assn. of Corrosion Engineers (NACE), American Society for Metals (ASM) and the Technical Assn. of the Pulp and Paper Industry (TAPPI).

. . . to your order

Debutinizers, exchangers, fractionating towers, pressure vessels or intricate processing equipment—you name it; we'll build it—to your requirements with exact precision. The size or shape is limited only by the customer's desire. Delivery on schedule is no problem by rail or water from our tidewater plant.

For forty years engineering leaders in the oil refining and chemical industries have been calling upon Sun Ship for important components for the building of large plants.

Let Sun Ship help solve your machine and equipment problem. Phone or write our Sales Engineering Department.



Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

Continued from page 40

gal./day of butane, 8,500 gal./day of natural gasoline. Tidewater will operate the unit, but share ownership with Tenneco Oil Co., Lone Star Producing Co., Edwin M. Jones Co. and others.

Du Pont plans to expand *p*-nitrochlorobenzene, *p*-nitrophenol, and *p*-nitrosodium phenolate capacities at its Chambers Works in Deepwater Point, N. J. Production of *p*-nitrochlorobenzene, which has been doubled in the past year alone, will be hiked to "several" million lb./yr. by late 1962. Additional capacity for *p*-nitrophenol and *p*-nitrosodium phenolate, both derivatives of *p*-nitrochlorobenzene, is expected to come on stream by mid-1962.

Air Products and Chemicals, Inc., has brought a $10-million oxygen plant on stream in Cleveland. Products: 600 tons/day of liquid and gaseous oxygen, nitrogen, argon and neon. One of five tonnage oxygen plants placed in operation this year by the firm, unit will pipe most of its gaseous oxygen output directly to Jones & Laughlin Steel Corp.'s basic-oxygen steelmaking furnaces.

Westinghouse Electric Corp.'s seawater desalting plant at Point Loma, Calif., is under construction. Being built by Westinghouse under Dept. of the Interior's demonstration desalting program, unit will use multistage flash evaporation to produce 1 million gal./day of fresh water for nearby San Diego residents. In the 10 evaporator vessels to the left (*above*), brine is routed through 36 flash-evaporation steps.

Wyandotte Chemicals Corp. has awarded Fluor-Singmaster & Breyer, Inc., a contract to design and construct a propylene oxide plant at Wyandotte, Mich. Construction will begin soon, with completion scheduled for next July. Neither cost nor capacity of the project has been disclosed.

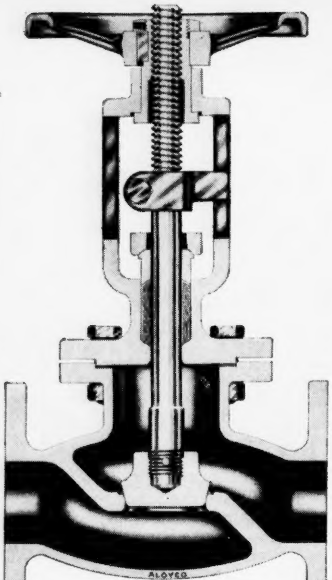
Koppers Co. plans to boost capacity by 25-30% at its Follansbee, W. Va., coal chemicals plant. Due completed in February, expansion will increase capacity for xylols and such tar acids as phenols, cresols and cresylic acids.

Companies

The Glidden Co., Cleveland, and **Pemco Corp.**, Baltimore, have merged. A producer of porcelain enamel, ceramic frits and inorganic colors, Pemco will be operated as part of Glidden's Chemicals Group. Under the terms of the merger, Glidden exchanged 199,840 shares of a new cumulative preferred stock issue for the 99,920 outstanding shares of Pemco common, a consideration of about $10 million.

Humble Oil & Refining Co., Houston, and **Olin Oil and Gas Corp.**, New Orleans, have reached "tentative agreement" on a plan by which Humble would acquire Olin for an estimated $68 million in stock. "Early" next year, Olin's 2,830,000 outstanding shares of common stock would be exchanged for an undisclosed number of shares in Humble's parent company, Standard Oil Co. (N. J.), in a tax-free exchange that must be approved by the government as well as Olin shareholders.

Cities Service Co., New York, has agreed to acquire **Fairway Oil and Gas Co.**, Tyler, Tex. By the move, Cities Service would get Fairway



Oil's 30% interest in leases covering about 7,000 acres of the rich Fairway field in Anderson and Henderson Counties, Tex. Cities Service Co.'s principal producing subsidiary, Cities Service Petroleum Co., Bartlesville, Okla., already holds a "substantial" interest in the gas field, will be operating approximately 40% of the field's known acreage when the acquisition of Fairway Oil is consummated.

Jupiter Oils Ltd., Chicago, and **Commonwealth Oil Co.,** Houston, have agreed to merge. New firm would be named The Jupiter Corp., a Delaware corporation, which would issue shares of a new preferred stock issue to Commonwealth shareholders. Jupiter Oils Ltd. is a diversified venture that currently operates in three areas: hotels and motels, printing, and oil and gas. Commonwealth Oil Co. operates an offshore gas-gathering system off the coast of Vermilion Parish, La.

International

Israel: Electrochemicals Industries (Frutarom) Ltd., Acre, has signed an agreement with Monsanto Chemical Co. under which the latter will provide the know-how for a $3-million polyvinyl chloride plant to be built at Haifa. Initial capacity will be 10-12 tons/day, ultimately to be hiked to 20 tons/day. Production is expected to begin in 1963. Electrochemicals Industries will create a subsidiary, Electrochemical Plastics Industries Ltd., to operate the PVC facility.

Spain: Centrales Nucleares S.A. (CENUSA) has been approved by Direccion General de Energia Nuclear, Spain's atomic-energy agency, to build a nuclear power station on the left bank of the Quadalquivir River near Seville in Andalusia. Plant will cost $50 million, produce 50 mw., be completed in 1968. Still pending approval by the regulatory agency are two other atomic-power projects: a similar nuclear plant proposed last summer by CENUSA, to be built on the Tagus River about 90 miles from Madrid; and a 600-mw. nuclear plant proposed by NUCLENOR, a privately held group of utilities in the north of Spain, to be built at Santa Maria là Garona on the Ebro River.

Australia: Imperial Chemical Industries of Australia and New Zealand Ltd. (ICIANZ) plans a $2.8-million carbon tetrachloride plant at Botany, in New South Wales. Due on stream by the end of next year, the petrochemical facility will feed on hydrocarbon stock from a nearby refinery. "A large part" of the output will be sold to two new firms, Australian Fluorine Chemicals Pty. Ltd., and Pacific Chemical Industries Pty. Ltd., to be used for making chlorofluorocarbons—a new industry for the continent. Scientific Design Co., New York, designed ICIANZ's carbon tetrachloride facility.

Canada: Howards and Sons (Canada) Ltd. has begun a $500,000 expansion of its Cornwall, Ont., facilities. Scheduled for completion early next year, new unit will produce up to 8,000 tons/yr. of sorbitol, a chemical used chiefly by tobacco makers to control the moisture content of their product. Currently, Canada imports about 2,500 tons/yr. of sorbitol from the U.S.

Jamaica: Caribbean Cement Co. is doubling its 200,000-ton/yr. cement capacity at Kingston. Expansion includes a third kiln, a new raw mill and a finish mill, plus an electricity-generating station being built by Macdonald Engineering Co., Chicago. Project will cost $6 million, come on stream in mid-1963.

People

Oscar G. Burch, vice president and technical director of Owens-Illinois Glass Co., has been named

president of the sixth International Commission on Glass. The congress is scheduled for next July 8-14 in Washington, D. C., to disseminate knowledge and promote understanding among 600 glass-technology scientists from both sides of the Iron Curtain.

G. Rodney Wick is the new director of engineering and research at General Aniline & Film Corp.'s Chemical Group.

R. Terrence Webster has been promoted to production manager for Stauffer Chemical Co.'s Stauffer Metals Div.

Hugh F. Gillespie has been appointed chief industrial engineer by Taylor Fibre Co. He takes charge of manufacturing methods and standards at the firm's Betzwood, Pa., plant.

Howard A. Benzel, vice president of engineering at Scott Aviation Corp., has been promoted to senior vice president.

H. W. Holly has been named product manager for urethane elastomers at American Cyanamid Co.

Ernest F. Upton, Jr., has been appointed director of engineering by Fischer & Porter Co.

Karl L. Fetters, vice president of research and development for Youngstown Sheet and Tube Co., has been elected president of The Metallurgical Society of AIME for 1962. **William B. Stephenson,** president of Allen-Sherman-Hoff Pump Co., has been named president of AIME's Society of Mining Engineers and vice president of AIME itself.

A. J. Buselli will join Texas Butadiene & Chemical Corp. as vice president of research and development. He has been director of research for W. R. Grace & Co.'s Polymer Chemicals Div.

Robert C. Hyatt has been promoted to general manager of General Aniline & Film Corp.'s Antara Chemicals Div.

Convention Calendar

January

9-11. American Society for Quality Control, American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn., National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C.

12-15. American Institute of Mechanical Engineers, Annual Meeting, New York, N. Y.

22-25. National Plant Maintenance and Engineering Show & Conference, Convention Hall, Philadelphia, Pa.

23-26. Canadian Pulp & Paper Assn., 1962 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Can.

26-2. American Management Assn. Quality Control, AMA Academy, Saranac Lake, N. Y.

31-2. University of California, Gas Chromatography Course, Los Angeles, Calif.

February

4-7. American Institute of Chemical Engineers, National Meeting, Hotel Statler, Los Angeles, Calif.

5-9. American Society for Testing Materials, Committee Week Meeting, Statler-Hilton Hotel, Dallas, Tex.

6-8. Society of the Plastics Industry, Reinforced Plastics Div. Conference, Edgewater Beach Hotel, Chicago, Ill.

12-15. 12th National Exposition of the Air-Conditioning, Heating and Refrigeration Industry, Great Western Exhibit Center, Los Angeles, Calif.

18-22. American Institute of Mining, Metallurgical & Petroleum Engineers, Annual Meeting, New York, N. Y.

21-23. Oklahoma State University, National Gas Conference, Stillwater, Okla.

March

1. Drug, Chemical & Allied Trades Assn., 36th Annual Dinner, Waldorf-Astoria Hotel, New York, N. Y.

4-7. American Society of Mechanical Engineers, Gas Turbine Power Conference & Exhibit, Shamrock-Hilton Hotel, Houston, Tex.

5-8. American Society of Mechanical Engineers, 7th Annual Gas Turbine Conference & Products Show, and 2nd Annual Process Industries Conference, Shamrock-Hilton Hotel, Houston, Tex.

13-14. Manufacturing Chemists' Assn., 2nd Symposium of Packaging of Chemical Products, Chase-Park Plaza Hotel, St. Louis, Mo.

13-15. Southwest Research Institute and Research Branch, Office of the Chief of Ordnance, Dept. of Army, Symposium on Application of Statistics and Computers to Fuels and Lubricants Research Programs, Granada Hotel, San Antonio, Tex.

14-16. Instrument Society of America, 12th Annual Conference on Instrumentation for the Iron & Steel Industry, Hotel Roosevelt, Pittsburgh, Pa.

15-23. American Society of Tool & Manufacturing Engineers, Engineering Conference anl Exhibit, Cobo Hall, Detroit, Mich.

19-23. National Assn. of Corrosion Engineers, Annual Conference and Show, Municipal Auditorium, Kansas City, Mo.

20-29. American Chemical Society, National Meeting, Washington, D. C.

April

2-4. National Petroleum Refiners Assn. Annual Meeting, Granada Hotel, San Antonio, Tex.

9-10. Instrument Society of America, 4th National Chemical & Petroleum Instrumentation Symposium, Wilmington, Del.

9-13. American Welding Society, 43rd Annual Convention & Welding Exposition, Cleveland Public Auditorium and Sheraton Cleveland Hotel, Cleveland, Ohio.

17-19. American Society for Metals, Regional Conference & Exhibition: Materials and Materials Processing for the Petroleum, Petrochemical and Chemical Industries, Shamrock-Hilton Hotel, Houston, Tex.

23-25. 1962 Powder Metallurgy Show, Hotel Sheraton, Philadelphia, Pa.

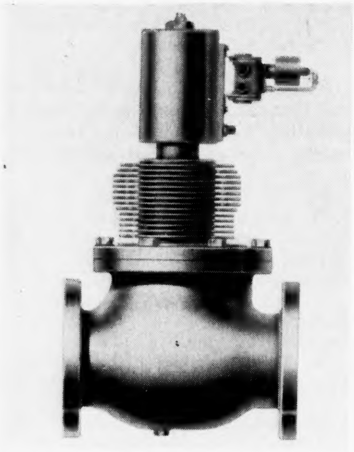
24-25. Chemical Engineering & Southwest Research Institute, Management of Petroleum and Petrochemical Operations, Granada Hotel, San Antonio, Tex.

25-27. Natural Gas Processors Assn., 41st Annual Convention, Denver-Hilton Hotel, Denver, Colo.

30-2. Instrument Society of America, 8th National Symposium on Instrumental Methods of Analysis Contact, Daniel Boone Hotel, Charleston, W. Va.

Continued from page 52

2 sec., according to the manufacturer. Applications include flue- and oven-gas analysis.—**The Hays Corp., Michigan City, Ind.** **52C**



Gas valve

Unit for remote operation serves at wide temperature extremes.

A full-flow shutoff valve provides remote actuation for either opening or closing by means of a 4-way solenoid. Normalizing fins have been designed to permit the unit to operate with fluids at temperatures ranging from −350 to +800 F.

Available in all ASA pressure ratings and sizes, ½ in. through 12 in., the valve is available with screw connections up to 2 in., flange connections above 2 in., and weld connections for all sizes. Body materials may be cast iron, carbon steel, stainless steel, or others that may be required.—**Security Valve Co., South Pasadena, Calif.** **120A**

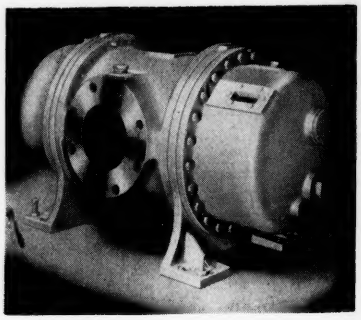
Vibrating mixer

Sealless unit can serve for both pressure and vacuum applications.

A unit called the Vibro-Mixer operates with only one moving part—a vibrating shaft and disk moving up and down in short, power strokes. It was described earlier in this department (*Chem. Eng.*, Nov. 27, p. 78) but more information is now available on its characteristics and performance.

In addition to being able to mix with comparatively low power-input, the device has no stuffing boxes or seals to cause trouble in closed systems, and no bearings or guides that require lubrication. Adjustable plain membrane seals are part of the unit, permitting pressures to 6,000 psi. in laboratory autoclaves, and to 500 psi. in industrial models—and, of course, full vacuum.

For work at high pressures, the vibration is transmitted through a radial to-and-fro movement instead of longitudinally along the shaft. Special stirring elements are used for both liquid and gas circulation under these conditions. —**Hudson Industries Corp., Newark, N. J.** **120B**



Gas meter

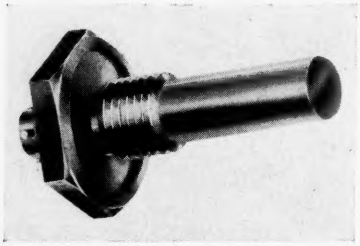
Positive-displacement unit has high capacity at pressures to 125 psi.

With a wide working range from low pressure to 125 psi., this rotary positive-displacement meter is available in capacities from 16,000 to 102,000 cfh.

In operation, two lobe-type impellers rotate with minimum clearances for accurate volumetric metering. Accuracy is said not to be affected by variations in specific gravity, fluctuating flows, or pressure pulsations. An easily read digital totalizer is standard equipment on each meter case.

Newly designed, the instrument is considerably lighter than pre-

vious models of the same line. Inlet and discharge connections are aligned to simplify piping during installation. An instrument drive and instrumentation for recording and telemetering can be furnished. **—Roots-Connersville Blower, div. of Dresser Industries, Inc., Connersville, Ind.** **120C**



Level controller

Ultrasonic device operates without depending on fluid properties.

An explosionproof ultrasonic switch controls liquid level under the most severe conditions. Unit is triggered instantly when any liquid touches the probe surface. Device can repeat within "thousandths of an inch," according to the manufacturer.

Unit operates in any position, is not affected by foam, droplets or film build-up. Also, the Sonoswitch requires no adjustment for temperature shifts or pressure variations, since it operates independently of fluid properties. Typical applications include over-fill alarms, automatic pump startup and shutdown, low-level indication. — **Powertron Ultrasonics Corp., Plainview, N. Y.** **122A**

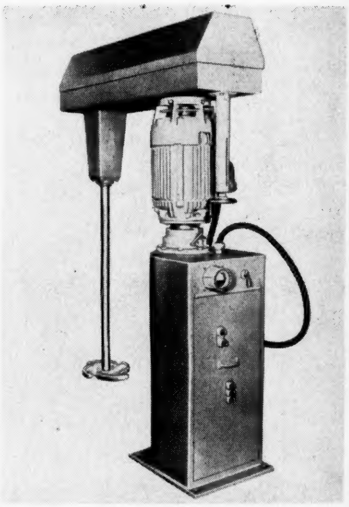
Flow control valve

Check valve and contoured needle aid in control at up to 5,000 psi.

For oil or air pressures up to 5,000 psi., this 1-in. control valve has a 5 to 1 safety factor. The unit incorporates a check valve that permits unobstructed flow in one direction, and a contoured needle that provides a wide range of flow adjustments in the opposite, or controlled, direction.

Frictional losses through the check valve are claimed to be low because as the ball moves off its seat, it seals off the spring chamber, isolating the spring and diverting the flow through a maximum-flow path.

Needle adjustments may be made under maximum rated pressure without effort. Special needle configurations and orifice openings are available to provide sensitive flow-control adjustments, or for large flow demands. — **Auto-Ponents, Inc., Bellwood, Ill.** **122B**



Mixer

Unit's mixer head can be raised or lowered hydraulically.

Called the type V. S. high-speed agitator, this unit has a built-in hydraulic cylinder that raises or lowers the mixer head. (Head can be raised 42 in. above operating position.) Mounted within the unit's control pedestal are a hydraulic pump and reservoir, hydraulic control valves and all-electric starters in an explosion-proof enclosure.

Mixer has variable-speed drive (from 600-2,100 rpm.), and is available with three different motors: 15, 20 or 25 hp. A handwheel adjusts speed of 2-in. shaft.—**Patterson Foundry and Machine Co., East Liverpool, Ohio.** **122C**

Briefs

Level-control system for liquid nitrogen in cold traps and other low-temperature vessels has an upper/lower-limit sensor mounted in a probe configuration. When level drops below a set lower limit, controller initiates transfer of liquid into the cold trap until upper limit is reached.—**Cryogenics, Inc., Stafford, Va.** **123A**

Desiccant dryer delivers low-dewpoint air for process and instrument use. Compact unit needs 110-v., a.c. power for electrical heater that reactivates desiccant material. Operating at inlet pressures from 10 to 90 psi., the device delivers air with a dewpoint of 100 F. below ambient temperature. —**Trinity Equipment Corp., Cortland, N. Y.** **123B**

Zone-melting unit refines and concentrates from 0.15 to 10 g. of organic compounds and other materials. Maximum temperature of 310 C. is obtained as a ¼ to ½-in. melting zone moves down a 6-in. glass tube at a rate of 1 in./hr.—**The Torsion Balance Co., Clifton, N. J.** **123C**

Equipment Cost Indexes . . .

	June 1961	Sept. 1961
Industry		
Avg. of all	236.9	237.2
Process Industries		
Cement mfg.	230.9	231.1
Chemical	237.3	237.7
Clay products	224.4	224.6
Glass mfg.	224.0	224.4
Paint Mfg.	229.4	230.3
Paper mfg.	228.6	229.0
Petroleum ind.	234.8	235.2
Rubber ind.	237.6	238.1
Process ind. avg	235.2	236.2
Related Industries		
Elec. power equip	235.1	235.8
Mining, milling	238.7	239.2
Refrigerating	268.6	269.1
Steam power	250.0	225.5

Compiled quarterly by Marshall and Stevens, Los Angeles, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for annual averages since 1913.

Technical Bookshelf

RING OUT THE OLD

The year has almost ended. And the tiers of Technical Bookshelf are groaning and swaying under the greatest tonnage of material ever. If literature progress can be measured by total weight, then 1961 has been far and away the most progressive literature year of all time.

Along with weight increase, however, has come a heightening of quality. We think this is due mostly to the entry of small publishing houses into the field, or to the expanding efforts of these firms. This competition has prodded the larger companies—already highly competitive with each other—to appreciably extend their efforts.

The result is a better product for you. It means better content and visual format. It means increasingly accurate and detailed indexing and cross-referencing. It means updated and more-comprehensive bibliographies. (Indirectly, to be sure, it also means an increase in price.)

We've tried to include a wide range of subjects in our reviews. Admittedly, some of the material achieves a narrow range of readership. But we attempt to do justice to the literature in all the many segments of the chemical process industries.

Here is a flash preview of some Technical Bookshelf features for 1962. An issue upcoming shortly will carry the results of a poll among *CE* editors on "What are the indispensable books for chemical engineers?" Then we've planned two "double reviews"—wherein two reviewers write independent critiques of the same work. And we've scheduled several reviews of new books on the basic subject of Chemical Engineering (seems to have been a shortage of these, but no longer.)

Also on deck: rundowns of the most recent outer-space texts and the latest volumes on methods of technical writing and scientific reporting.

Until next year, merriest season's greetings!—HSG

Technical Bookshelf

RING OUT THE OLD

The year has almost ended. And the tiers of Technical Bookshelf are groaning and swaying under the greatest tonnage of material ever. If literature progress can be measured by total weight, then 1961 has been far and away the most progressive literature year of all time.

Along with weight increase, however, has come a heightening of quality. We think this is due mostly to the entry of small publishing houses into the field, or to the expanding efforts of these firms. This competition has prodded the larger companies—already highly competitive with each other—to appreciably extend their efforts.

The result is a better product for you. It means better content and visual format. It means increasingly accurate and detailed indexing and cross-referencing. It means updated and more-comprehensive bibliographies. (Indirectly, to be sure, it also means an increase in price.)

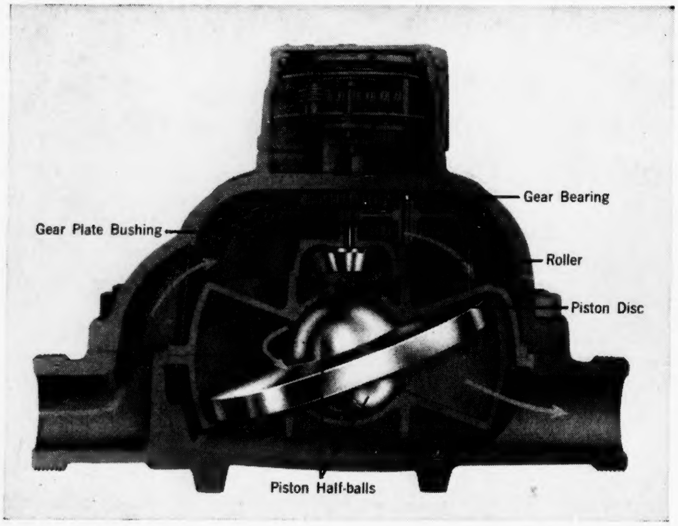
We've tried to include a wide range of subjects in our reviews. Admittedly, some of the material achieves a narrow range of readership. But we attempt to do justice to the literature in all the many segments of the chemical process industries.

Here is a flash preview of some Technical Bookshelf features for 1962. An issue upcoming shortly will carry the results of a poll among *CE* editors on "What are the indispensable books for chemical engineers?" Then we've planned two "double reviews"—wherein two reviewers write independent critiques of the same work. And we've scheduled several reviews of new books on the basic subject of Chemical Engineering (seems to have been a shortage of these, but no longer.)

Also on deck: rundowns of the most recent outer-space texts and the latest volumes on methods of technical writing and scientific reporting.

Until next year, merriest season's greetings!—HSG

Chemical Division 3M COMPANY



KEL-F® BRAND PLASTIC foils corrosive attack, keeps meters on the mark!

Equipment that measures even highly corrosive liquids can be enduringly exact, too! Buffalo Meter Company manufactures meters that measure precisely the flow of over 100 corrosive chemicals, including acetic acid, aluminum nitrate, carbon bisulfide, diethylamine, phosphoric acid, potassium chloride and concentrated sulphuric acid. Vital meter parts—piston discs, half balls and other components, as shown—are made of KEL-F Brand Plastic because it retains its shape and dimension in the presence of corrosive chemicals, even fuming nitric acid.

Other properties which led to the selection of KEL-F Plastic for this application include stability, easy moldability, low cold flow, low specific gravity and good lubricating qualities. The five meter components of KEL-F Plastic are molded for Buffalo Meter Company by Resistoflex Corp., Roseland, N.J., and the Garlock Packing Co., Palmyra, N.Y.

Now, new KEL-F 81 Plastic incorporates many property advantages, along with better-than-ever uniformity and consistency. For more information, read the "profile" to the right, then return the coupon below.

Chemical Division, Dept. KAL-121
3M Company
St. Paul 6, Minn.

TELL ME MORE...
about KEL-F 81 Plastic

Name__________
Title__________
Company__________
Address__________
City & State__________

Properties Profile on KEL-F® BRAND 81 PLASTIC

KEL-F 81 Plastic is a fluorocarbon plastic, a thermoplastic resin formed by the homo-polymerization of chlorotrifluoroethylene. The high degree of fluorination of KEL-F 81 Plastic is responsible for its chemical inertness and thermal stability. The inclusion of chlorine in an otherwise carbon-fluorine molecule results in exceptional moldability and mechanical toughness.

Crystallinity. KEL-F 81 Plastic is crystallizable, but not necessarily crystalline, the degree and kind of crystallinity in a given sample being a function of its thermal history. The "quick-quenched" resin is spoken of as amorphous, and the "slow-cooled" resin as crystalline. When crystalline, KEL-F 81 Plastic is a denser, more translucent material with higher tensile modulus, lower elongation, and greater resistance to the penetration of liquids and vapors. The amorphous plastic is less dense, more elastic, with greater optical clarity and toughness.

Physical Properties. The physical properties of KEL-F 81 Plastic combine mechanical, chemical, electrical, and optical advantages. And the most useful applications center around combinations of the following properties:

1. Useful temperature range: from —400° F. to +400° F.
2. Resistance to deformation and flow at high temperatures, pressures
3. Zero moisture absorption
4. Abrasion resistance
5. Radiation resistance
6. Chemical resistance
7. Electrical properties
8. Infrared transmission
9. Inert to liquid oxygen
10. Flexible in contact with cryogenic fuels

Processing. KEL-F 81 Plastic can be processed in the same manner as other thermoplastic resins. Parts of KEL-F 81 Plastic may be specified in any form.

Detailed data on physical properties is contained in a new free brochure. For your copy, return coupon or write to 3M Chemical Division, stating area of interest.

"KEL-F" is a reg. TM of 3M Co.

MINNESOTA MINING & MANUFACTURING CO. 3M

CHEMICAL ENGINEERING

Volume 68

1961

Published biweekly by
McGRAW-HILL PUBLISHING COMPANY, INC.
NEW YORK

Chemical Engineering

J. ELTON TUOHIG
Publisher

CECIL H. CHILTON
Editor-in-Chief

In August 1946 *Chemical & Metallurgical Engineering* was renamed *Chemical Engineering. Chemical & Metallurgical Engineering* was the successor to *Metallurgical & Chemical Engineering,* which, in turn, was a consolidation of *Electrochemical & Metallurgical Industry and Iron & Steel Magazine.* The magazine was originally founded as *Electrochemical Industry.*

McGRAW-HILL PUBLISHING COMPANY, INC., NEW YORK CITY

Volume 68

January to December 1961

GENERAL ALPHABETICAL INDEX

A

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

B

C

NOTES—•Illustrated; (N) News; (P.N.) Plant Notebook

D

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

E

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

F

NOTES—•Illustrated; (N) News; (P.N.) Plant Notebook

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

O

P

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

U

V

W

X

Z

NOTES—*Illustrated; (N) News; (P.N.) Plant Notebook

AUTHOR INDEX

FOR MORE INFORMATION

- Advertised Products
- New Equipment
- New Chemicals
- Manufacturers' Literature
- Classified Advertisements

Also . . .

- Reprint orders
- Subscriptions

Your Reader Service card is fastest.

USE EITHER CARD

They're easy to fold and tear out . . . try it . . .

PLEASE PRINT *

NAME:

TITLE:

COMPANY:

NO. OF EMPLOYEES:

PRODUCT:

ADDRESS:

CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

PLEASE PRINT *

NAME:

TITLE:

COMPANY:

NO. OF EMPLOYEES:

PRODUCT:

ADDRESS:

CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

Help Yourself . . .

The postcards above can now bring you technical help, latest literature, expert guidance. Tear one out and, as you read this issue, circle numbers when you want more information. You'll note that the coding system is simple: all the code numbers are page numbers.

You can also use these post-paid cards to subscribe, or to make your selection from a comprehensive list of editorial reprints.

*** Be sure to fill in all of these address blanks before mailing postcard.**

26

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.)

To

CIRCLE code numbers for more information. (This Dec. 25, issue card will expire March 25, 1962)

Cov	14-15	33b	43A	49	57	95	115a	117	122c	B125	150D	154D	159	162A
1	16	33c	43B	50A	58	97	115b	118	122A	126	150E	155	159A	162B
2	18a	35	44A	50B	59	99	115c	119	122B	148	151	156	T160	162C
8-9a	20-21	39	44C	52A	64	103	115e	120A	123	148B	152A	156B	160A	162E
8-9b	23	41	44D	52B	65	105	115f	120B	123A	149	153	157	161	162F
8-9c	25	42A	44E	52C	66	107	115g	120C	123B	150	154	158	161A	162G
8-9d	29	42B	45	53	83	109	115h	121	123C	150A	154A	158A	161B	170
10-11	31	42C	46-47	54-55	91	111	115i	122a	124	150B	154B	158B	161C	171
12-13	33a	42D	48A	56	93	114	116	122b	T125	150C	154C	158C	162	172

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB

CIRCLE KEY NUMBERS for more information about . . .
- **ADS**
- **PRODUCTS** page 42
- **EQUIPMENT** page 48
- **SERVICES**
- **LITERATURE** page 148
- **CLASSIFIED**

REPRINTS: Circle what you want. (See opposite page for description)

40	42	45	49	50	52	54	57	59	61	62	63	64	66	67	68	70	72	73	74	75	76
78	79	80	81	82	83	85	86	87	88	89	90	91	92	94	97	98	99	100	101	102	103
105	107	108	109	110	111	112	113	114	115	117	119	120	121	122	123	124	125	126	127	129	130
131	133	135	136	138	139	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178
179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	197					

REPRINTS (While they last)

FREE REPRINT: Check here ☐ for your file copy of this issue's free reprint. (p. 89) FC 77

26

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.)

To

CIRCLE code numbers for more information. (This Dec. 25, issue card will expire March 25, 1962)

Cov	14-15	33b	43A	49	57	95	115a	117	122c	B125	150D	154D	159	162A
1	16	33c	43B	50A	58	97	115b	118	122A	126	150E	155	159A	162B
2	18a	35	44A	50B	59	99	115c	119	122B	148	151	156	T160	162C
8-9a	20-21	39	44C	52A	64	103	115e	120A	123	148B	152A	156B	160A	162E
8-9b	23	41	44D	52B	65	105	115f	120B	123A	149	153	157	161	162F
8-9c	25	42A	44E	52C	66	107	115g	120C	123B	150	154	158	161A	162G
8-9d	29	42B	45	53	83	109	115h	121	123C	150A	154A	158A	161B	170
10-11	31	42C	46-47	54-55	91	111	115i	122a	124	150B	154B	158B	161C	171
12-13	33a	42D	48A	56	93	114	116	122b	T125	150C	154C	158C	162	172

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB

CIRCLE KEY NUMBERS for more information about . . .
- **ADS**
- **PRODUCTS** page 42
- **EQUIPMENT** page 48
- **SERVICES**
- **LITERATURE** page 148
- **CLASSIFIED**

REPRINTS: Circle what you want. (See opposite page for description)

40	42	45	49	50	52	54	57	59	61	62	63	64	66	67	68	70	72	73	74	75	76
78	79	80	81	82	83	85	86	87	88	89	90	91	92	94	97	98	99	100	101	102	103
105	107	108	109	110	111	112	113	114	115	117	119	120	121	122	123	124	125	126	127	129	130
131	133	135	136	138	139	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178
179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	197					

REPRINTS (While they last)

FREE REPRINT: Check here ☐ for your file copy of this issue's free reprint. (p. 89) FC 77

For Subscriptions: To apply, check here..........

(Pay when billed) Where to send subscriptions..........

Want More Data?

Important—Code numbers are page numbers and for pages showing more than one advertised item, use this guide to numbers on cards above.

Use either of these two postcards for catalogs . . . for more information on equipment . . . on materials . . . on advertised items . . . for helpful reprints of editorial articles. Be sure to fill out the other side of cards.

8-9a—Cyana-Guard

8-9b—Beetle Urea Plastic

8-9c—Acrylic Fiber Sheet

8-9d—Hydrogen Cyanamid

18a—Floodlights

18b—Hand Lamps

33a—Pump, Model 3195

33b—Maintenance Record Cards

33c—Alloy Pump, Model 3139

115b—Ro-Ball Sifters

115c—Ribbon Blenders

115d—Titan Mixers

115e—Pony Fixers

115f—Nauta Mixers

115g—Regal Mixers

115h—3-Roll Mills

115i—Hy-R Speed Mills

122a—Micro Filter, Series C

122b—Micro Filter, Series M

Reprints Now Available

CE editorial reprints are now easy to get—use Reader Service Card for fast service.* For each reprint you want just circle its number on the card. Fill in the blanks on the front, mail. Send remittance if you wish.

For a new reprinting of Chemical Engineering's cost estimating articles; **see p. 162**

• MATERIALS OF CONSTRUCTION

Corrosion—Refresher on cause & cure ($1)...........131
High-Temperature Materials—Inorganic, nonmetals (75¢).120
High-Temperature Metals—Selection, directory ($1)....129
Lead Installations—Best designs for many uses (50¢).. 79
Nonmetallic Inorganics—For severe conditions (50¢)...125
Plastic Pipe—How and when to use (75¢).............135
Process Piping Materials—Selection directory ($1).....169
Protective Linings—Choice, application, directory ($1).. 88

• PROCESSES

Advanced Chemical Rocket Propulsion Systems (50¢)...179
Bio-oxidation—Treatment of wastes (50¢)............. 68
Chemicals From Petroleum—Available processes ($1)..139
Chemical Rocket Propulsion Systems (50¢)...........177
Extractive Metallurgy—By chemical processing (50¢)..111
Ultra-Low Temperatures—Production and uses (50¢)...133
Fermentation—Its chemical technology (50¢).......... 74
High-Temperature Technology—Materials, uses (50¢).. 91
Manufactured Gas—To supplement natural gas (50¢)...115
Moving Bed Processes—Theory plus application (75¢).. 64
Nuclear Industry—Role of chemical engineers (50¢).... 89
Nuclear Wastes—Treatment and disposal (50¢)........150
Odor Control—How to be a good neighbor (50¢)........ 98
Operation & Maintenance—The impact of trends ($1)...121
Photochemical Engineering—Uses, equipment (75¢).... 59
Plants & Facilities—10th Inventory, 1959 (75¢)........158
Plants & Facilities—11th Inventory, 1960 (50¢)........167
Plants & Facilities—12th Inventory, 1961 (50¢).........178
Processes & Technology—9th Inventory, 1959 (50¢)....159
Processes & Technology—10th Inventory, 1960 (50¢)...171
Processes & Technology—11th Inventory, 1961 (50¢)...184

• CHEMICAL ENGINEERING SCIENCE

Analog & Digital Computers—In engineering use (50¢)..145
Conference on the New Chemical Engineering ($1.50)..173
Pilot Plant—All the aspects of scale up ($1)...........127
Speculative Process Design—Pilot plant bypass (50¢)..146
Statistics—How to use data effectively (75¢)........... 73
Systems Engineering—86-page review ($1.25)..........181
CE Refresher
Thermodynamic Principles (50¢).................... 42
Compression & Expansion (50¢).................... 45
Chemical Equilibrium (50¢)........................ 49
Homogeneous Kinetics (50¢)....................... 57
Catalytic Kinetics (50¢).......................... 61
Interpreting Kinetics (50¢)........................ 66
Simple Reactor Design (50¢)....................... 72
Complex Reactor Design (50¢)..................... 75
Catalytic Reactor Design (50¢).................... 81
Reactor Design Problems (50¢).................... 87
Physical Equilibrium I (50¢)...................... 90
Physical Equilibrium II (50¢)..................... 97
Fluid Flow Equations (50¢)........................101
Fundamental Mathematics (75¢)....................113
Mass Transfer Operations ($1).....................130
Unit Operations Refresher
Fluid Flow (50¢)................................144
Sedimentation Theory (50¢).......................148
Heat Transfer (50¢)..............................155
Unsteady State Heat Transfer (50¢)................164
Absorption Methods (50¢).........................168
Distillation (75¢)................................180
Simultaneous Heat & Mass Transfer (50¢)...........187

• EQUIPMENT AND DESIGN

Air Pollution—CPI plant solutions (50¢)..............143
Control Valves—Behavior and selection (75¢)..........141
Disaster Control—Plan in advance (50¢)...............186
Electrical Safety—Design methods (50¢)...............185
Estimating Engineering Properties
Thermal Cond. (50¢)...94
Heat Capacities (75¢).109
Latent Heat (75¢).....117
Surface Tension (75¢).126
Viscosity (75¢) 138
Critical Properties (75¢).149
Other Physical Properties (50¢) 151
Flow Sheets—Engineering communiques (50¢)......... 99
Flow File—50 design formulas (50¢).................112
Flow Through Packing and Beds
Packed Towers (50¢)..............................103
Fixed and Moving Beds (50¢)......................107
Fluidized Systems (50¢)..........................108
Heat Exchanger Design—Shortcut methods (75¢)...... 52
Heat Exchanger Calculations—Use these charts ($1)...136
Mechanical Seals—How to select and use (50¢)........ 83
Non-Newtonian Fluid Flow—Scaleup ($1).............188
Packaging—Unit containers for chemicals (50¢)........166
Piping—Roundup of process pipe, valves, fittings (75¢).. 40
Process Control—Instrumentation report ($1).........183
Process Design: Fluid Flow—Size lines, pick pumps ($1).161
Pump Seals—Chemical plant practice (50¢)............ 92
Water Conservation—Will taps run dry? (50¢).........105
Water Pollution—Solve plant problems (50¢)..........122
Your Design Reference File
Parts I-V (75¢) 100
Parts VI-IX (75¢).................................110

• COSTS AND COMMERCE

Buyer-Seller Relations—Vendor's view (50¢)...........157
Capital Cost Estimating—Data, sources & methods ($1).156
Capital Investments—Appraisal methods (50¢)........182
CE Cost File, 1959—Quick estimating data (50¢).......153
CE Cost File, 1960—Quick estimating data ($1).........172
Cost Control Systems—Reduce and control costs (50¢).102
CPI Forecast for '61 (50¢)...........................170
Inflation—How to predict a shrinking dollar (50¢)...... 78
Operator Shift Schedules—How to organize (50¢)......175
Patent Fundamentals—Timely review (50¢)............114
Petrochemicals—1958 economic review (50¢)..........123
Petrochemicals—1960 economic review (75¢)...........176
Petrochemicals—What's ahead (50¢)..................189
Process Energy—Make or buy? (50¢)..................142
Professional Registration—For PE-minded ChE's (50¢). 85
Rockets and Missiles—Airborne reactor problems (75¢).119
60's Challenge Chemical Engineers (50¢)..............152

• UNIT OPERATIONS

Absorption With Chemical Reaction (50¢).............162
Adsorption—Design, methods, materials (50¢).........154
Azeotropic Separation—Close-boiler distillation (50¢)...160
Batch Distillation of Binary Mixtures (50¢)............174
Binary Distillation—Theory, equipment (75¢)........... 54
Compressible Fluids—How to handle ($1)............. 80
Crystallization—For purification (50¢)...............124
Drying—Methods, equipment, design, cost (75¢)....... 70
Foams—How to use and control (50¢)................. 86
Liquefied Compressed Gases—Handle with care (50¢)..147
Liquid-Gas Contacting—A practical study (75¢)........ 82
Liquid Proportioning—Equipment, methods, uses (50¢).. 76
Lubrication—For chemical plant engineers (50¢)....... 50
Plant Startups—Systematic preparation (50¢)..........165
Solids Concentration—Survey of techniques (50¢)...... 67
Solids-Gas Contacting—Commercial practice (50¢)..... 63
Solids—Liquid Separation—Operations, descriptions ($1) 62
Solid-Solid Blending—Theory, practice, equipment (75¢).163

RECENT REPRINTS—TO KEEP YOUR FILES UP-TO-DATE

Engineering Standards—At home and abroad (50¢)..192
Multicomponent Distillation (50¢)..................194
New Trends in Chemistry ($2)......................197
Plants & Facilities—13th Inventory, 1961 (50¢)......191
Transport Phenomenon—Refresher (50¢)...............193
Ultrasonics in Processing—Uses and trends (50¢)....190

***Don't forget to check the Free Reprint box for your extra copy of this issue's reprint feature** **(p. 89)**

Manufacturers' Literatu

Contents of This Issue

Chemicals

Acrylic Monomers.......New, revised bulletin gives up-to-date information on storage and handling of acrylic monomers. Write to Dept. SP-31 for your copy.
121 *Rohm & Haas

Activated Carbon......A complete line of activated carbons for every purpose; design and prefabricate complete purification, separation & recovery systems. Bul. J-122.
170 *Barneby-Cheney

Activated Carbon.......An illustrated brochure contains basic design techniques for both liquid and vapor phase, continuous column adsorption systems.
49 *Pittsburgh Chemical Co.

Ammonium Sulfate......B & A ammonium sulfate is purified and is a primary product of selected raw materials not a by-product. For processing foods & pharmaceuticals.
25 *Allied Chem., Gen. Chem. Div.

Catalog......75-page catalog lists and describes industrial chemicals for international sale and also provides information on packaging and application.
148A Diamond Alkali Co.

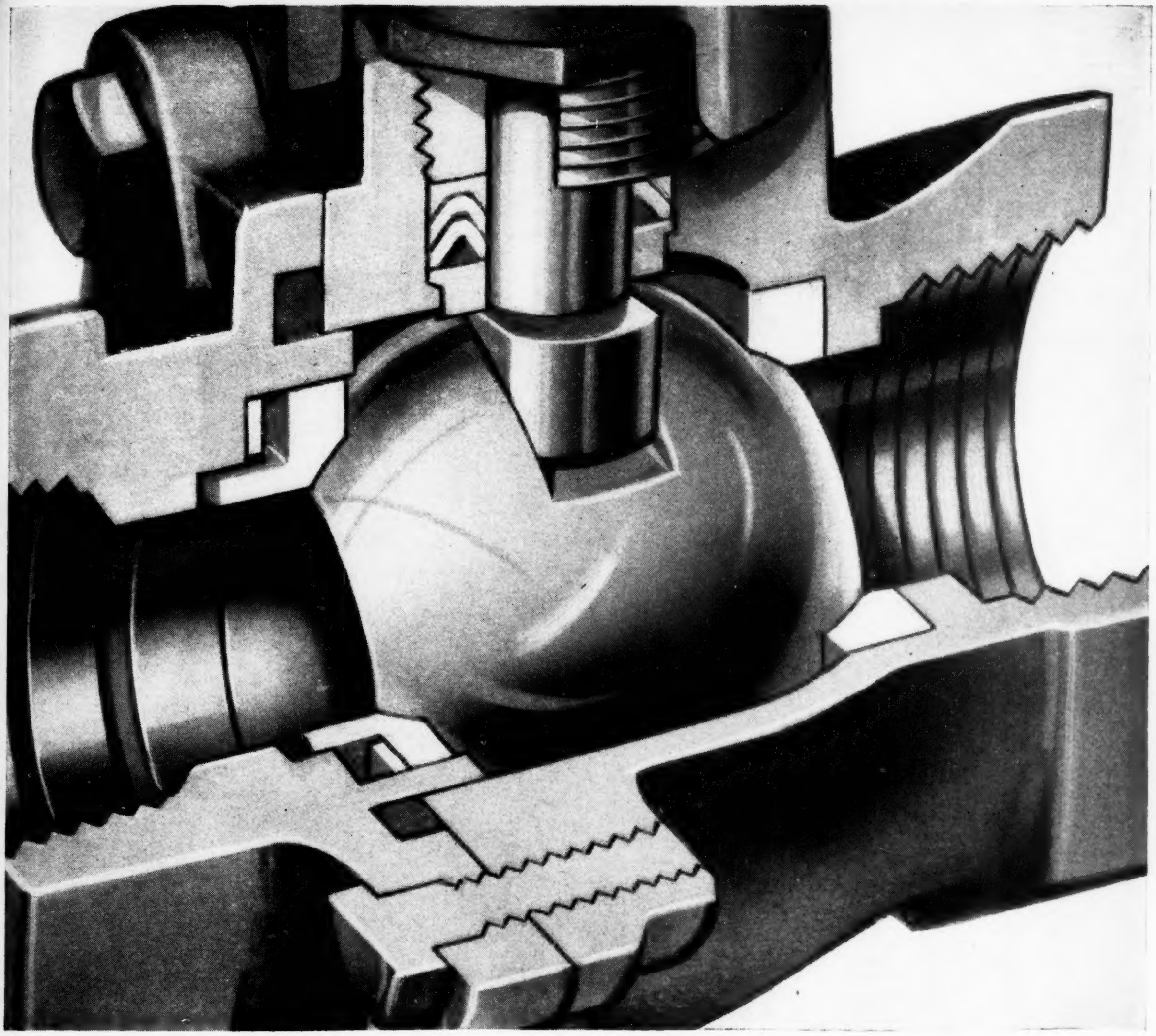
Furfuryl Alcohol.......has a marked effect on the properties of urea-formaldehyde, phenol-formaldehyde & epoxy resins. Details on furfuryl alcohol in Bul. 205.
37 *Quaker Oats Co.

Hydrogen Cyanamide......The cyanamide radical is now available as a stable, colorless, concentrated 50% aqueous solution of hydrogen cyanamide. Information.
8-9d *American Cyanamid Co.

Meta-phenylenediamine........43-page bulletin I-23 describes chemical used as a curing agent for epoxy resins and as an intermediate in dye synthesis.
148B National Aniline Div.

* From advertisement, this issue

TAKE A CLOSE LOOK AT ROCKWOOD BALL VALVES



How important is "choice"?

Few valve installations have identical characteristics. That's why you should look into the wide choice available in Rockwood Ball Valves. Rockwood Valves offer all these characteristics in various combinations: Castings of stainless and carbon steel, or bronze . . . flanged, sweat or screw ends . . . rubber, Teflon, nylon or Kel-F *ball seats* . . . lever, gear, air, electric or hydraulic *operation* . . . *pipe sizes* from ⅜″ to 14″.

When you call in a Rockwood man, you're sure to get the valve *you need* — not just the valve *he has* to sell.

And Rockwood Ball Valves have these important advantages:

Larger waterway diameters for smoother flow.

Ease of maintenance — no lubrication is needed; most parts replaceable with ordinary tools.

Spring-loaded ball seats for longer, tighter sealing.

Reliability — backed by the time-proven experience of the pioneer in modern ball valve design.

Your Rockwood man can provide full details, or write Rockwood Sprinkler Company, Ball Valve Department, 278 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD

BALL VALVES

LITERATURE . . .

Methylpyrrolidone.......A stable lactam featuring high solvent capacity, maximum safety, and miscibility with organic solvents and water is described in bulletin.
150A Antara Chemicals

Plastic.......A new brochure giving complete technical data on Kel-F 81 plastic is available. Contains complete laboratory and test data on chemical and physical properties.
126 *Minn. Mining & Mfg. Co.

Products.......Catalog lists lithium chemicals, metal and minerals, welding grade products etc. for application in chemical, metallurgical etc. industries.
150B Foote Mineral Co.

Sodium Isethionate......10-page bulletin AP-103 describes properties and uses of difunctional chemical intermediate used in the manufacture of many compounds.
150C Antara Chemicals

Styrene Monomers......16-page bulletin 170-133 discusses styrene, vinyltoulene, divinylbenzene and alpha-methyl-styrene monomers and includes numerous graphs and charts.
150D The Dow Chemical Co.

Tar Bases.......6-page booklet treats in chart form the specifications and properties of selected tar bases including quinaldine, pryidines, quinoline etc.
150E Allied Chemical Corp.

Textile Chemical......Cyana-Guard is now used in the dry cleaning process to restore moisture to clothes and to prevent perspiration odor from developing. Information.
8-9a *American Cyanamid Co.

Thinners......Tolu-Sol thinners allow you to choose the precise solvency you need. Information is contained in Technical Bulletin SP-61-2 which is available.
46-47 *Shell Oil Company

Urea Plastic......Beetle urea plastic is corrosion-proof and has good heat resistance and does not build up dust-attracting static charges. Further information.
8-9b *American Cyanamid Co.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

It's easy — simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

New Westinghouse digital draw-speed indicator instantly reports precise strip process speeds and speed differentials

Immediate knowledge of speed differentials, surface speeds, section speeds, speed ratios, improper slack, and drift is vital to improved product quality, uniformity, and output in the strip process industries.

The new Westinghouse digital draw-speed indicator has been designed to meet your accurate process speed requirements. This digital instrument measures surface speeds, speed difference between sections, and speed ratios between sections with accuracies of .1 foot per minute or 1 foot per minute. The completely transistorized digital indicator is entirely free from drift and retains its initial accuracy indefinitely.

This versatile product continually monitors speeds and draws, allowing fast location and trouble shooting of the causes of machine variations. In addition, it isolates the source of trouble to either regulator or mechanical problems.

It provides information that eliminates trial-and-error machine set-up. It permits the operator to accurately set up the ideal speed or draw on any given machine section, based on recorded data from previous runs.

Already proven in the paper and plastics industries, this new development is well suited to other strip process industries such as aluminum, steel, textile and rubber.

For more information, contact your Westinghouse representative or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.
You can be sure . . . if it's Westinghouse.

J-40540

Westinghouse

LITERATURE . . .

Construction Materials

Acrylic Fiber Sheet......is resistant to common solvents, most chemicals and ultraviolet light. This material is adaptable to a wide variety of uses. Information.
8-9c *American Cyanamid Co.

Coating......Dimecote coating resists weathering, salt spray, petroleum products and severe abrasion for long periods of time. Technical data are available.
111 *Amercoat Corp.

Fabrication.......Plate work of all kinds and sizes. Equipped with modern fabricating facilities & strategically located for rail, truck or water shipment.
10-11 *U. S. Steel, Amer. Bridge Div.

Glass Fabrics.......Many weaves of glass fabrics engineered for liquid filtration, plastics lamination, high temp. dust collection or insulation. Samples are offered.
154 *National Filter Media Corp.

Insulation......The new Industrial Insulation Catalog is offered. Also Data Sheets on the complete line of accessories for use with Foamglass insulation.
103 *Pittsburgh Corning Corp.

Nuclear Graphite......No other material has so many useful nuclear properties. It is an excellent structural material, resists corrosion & is easily fabricated.
91 *The National Carbon Co.

Protective Coatings.......Polyken 960 is a dependable pipeline coating. Easy to handle, simple to apply, & its cathodic protection requirements are low. Details on request.
53 *The Kendall Co.

Silicone Paint......to resist weathering, to resist heat, to resist discoloration and to resist corrosion. Formulating and technical data are offered.
99 *Dow Corning Corp.

Tank Linings......New Gar-Line Penton linings offer high-temperature protection against corrosion. Data on Penton; information on tank linings.
101 *Garlock, Inc.

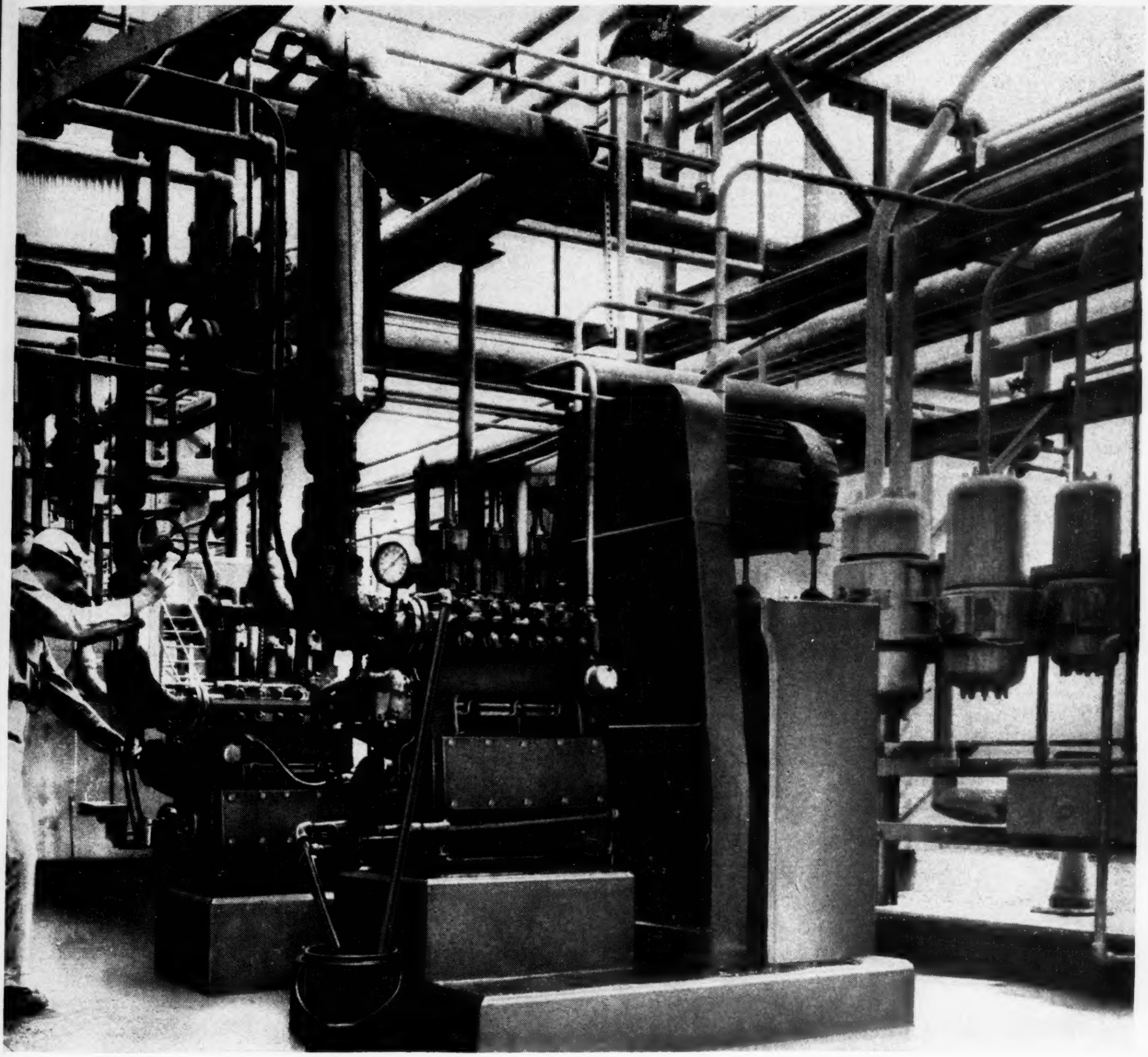
Electrical & Mechanical

Electric Trucks......The exclusive features that enable these trucks to deliver up to 60% more work in low speeds per battery charge are explained in 12-page brochure.
152A Automatic

Floodlights.......for any explosion-prone area. A catalog is offered giving descriptions of floodlights for explosion-proof illumination. Catalog Number 320.
18a *Crouse-Hinds

Gas Turbines......Specialized installation, maintenance from Solar's experienced field service engineers. Write Dept. J-168 for info on gas turbines, field service program.
155 *Solar, sub. Internat'l Harvester

* From advertisement, this issue



LITERATURE . . .

Power Recovery Turbine......designed for power recovery from any gas mixture. Further information on any power recovery turbine application is available.
Cover *Worthington Corp.

Speed Drives........Adjustable-speed drives in sizes from ½ to 2500 hp. Information is contained in Bulletin 2900, Adjustable Speed Drives, which is available.
58 *The Louis Allis Co.

Speed Reducers.......36-page catalog includes handbook information to help select right-angle bevel-helical gear reducers and provides rating charts.
154A D. O. James Mfg. Co.

Unilets, Aluminum......The line includes 7 of the most popular types in ½", ¾" & 1" sizes. Bulletin No. AL 60 includes details for the entire aluminum product line.
1 Appleton Electric Co.

Universal Joints......6-page engineering bulletin No. 513 describes series of universal joints with torque capacities ranging from 4,250 to 12,700 lbs.-ft.
154B Twin Disc Clutch Co.

Handling & Packaging

Conveyor Belts......Metal-mesh belts for such diversified operations as bagging cement, drying wool, etc. A 130-pg. Reference Manual gives specifications, etc.
65 *The Cambridge Wire Cloth Co.

Dimple Jacketed Tanks......This construction saves 20 to 30%. The jacket is ASME approved to 162 p.s.i. Details are found in Bulletin BF-6 which is offered.
105 *Brighton Corp.

Screw Conveyor Components........A single component or complete systems—for standard or special requirements. Details are available on the complete line to match your need.
16 *Link-Belt Company

Tanks......Largest seamless reinforced plastic tanks available up to 11½ feet in diameter. For complete info on low cost, corrosion-free service request Catalog No. 110.
152 *du Verre Inc.

Vibrating Screens......48-page booklet 2777A describes ten different types of screens in 214 sizes and contains tables of materials, and cutaway photographs and drawings.
154C Link-Belt Co.

Heating & Cooling

Air Heaters......Bulletin #AH-61 describes three basic types of single burner gas, oil or combination direct fired units and discusses firing and auxiliary control equipment.
154D Coen Co.

Coils, Smooth-Fin........offer greater heat transfer per sq. ft. of face area and lower airway resistance—less power per c.f.m. Further details in Bul. S-55.
148 *Aerofin Corp.

* From advertisement, this issue

NEW SUBSCRIPTION APPLICATION

Subscriptions Accepted Only From CPI Engineers, Technical Management and Senior Students. Cards Must Be Filled-In Completely Before Service Starts — Students Please Include Class, Major Field and School.

*Rates for U.S. and U.S. Possessions Only**

☐ **3 years of CHEMICAL ENGINEERING for $5**

☐ Bill me
☐ Bill my company
☐ Payment enclosed

*Foreign 1 Yr.: Canada $4
West. Hem. $15 • Others $25

☐ ✓ HERE for 1 YEAR @ $3

Please Print

Name__________ Title__________

Home Address__________

City__________ Zone_____ State_____

Company & Department__________ Approx. No. of Employees in Plant_____

Product(s)__________ ☐ Manufacturer ☐ Wholesaler

K

M

12-25-61

BUSINESS ADDRESS

Street__________ City__________ Zone_____ State_____

☐ Check here if you want publication sent to business address

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL

No Postage Stamp Necessary If Mailed In The United States

POSTAGE WILL BE PAID BY—

CHEMICAL ENGINEERING

330 WEST 42nd STREET

NEW YORK 36, N. Y.

TURBOMACHINERY EXPERT

Gas turbine users get specialized installation, maintenance from Solar's experienced field service engineers

Solar field service engineers serve Solar gas turbine customers anywhere, anytime. These trained experts know gas turbines. Many have worked with Solar turbine installations for 10 years. They know how to tailor turbines to specific jobs; they know turbine maintenance.

More and more of Solar's versatile, high performance engines are being used in industry where their light weight, high horsepower and small size mean more efficiency. As a new kind of powerplant, however, gas turbines represent changes in existing methods of installation and maintenance. So Solar sells more than gas turbine engines—it sells experienced customer service too.

Solar's customer service department acts fast to help turbine customers. Immediately following receipt of an order, the department makes complete plans for assisting in the installation and operation of the engine.

The customer service department's team of field service engineers is equipped with current passports and security clearances. Their experience and ability equips them to handle field work and to train customer personnel.

Because of Solar's customer service program, companies without gas turbine experience can take advantage of this engine's superior performance. Solar's customer service department offers on-the-spot help and off-the-shelf spare parts for fast, efficient service.

For information about Solar gas turbines or field service program, write Dept. J-168, Solar, San Diego 12, California.

SOLAR

A subsidiary of International Harvester Company

LITERATURE . . .

Cooler, Aero After......Gives bests results for compressed air-operated instruments or pneumatic equipment. Write for Bulletin 130 if you have problem on industrial use of air.
B160 *Niagara Blower Company

Heat Control......Equipment such as temperature-pressure regulators, float thermostatic steam traps, thermo-dynamic steam traps and pipeline strainers. Inform.
93 *Sarco Company, Inc.

Heat Exchangers......Bulletin 500, a 10-page catalog, describes four basic types of bundle type heat exchangers and points out operating advantages of each.
156A Brown Fintube Co.

Heat Exchangers......Helpful information on the design and fabrication of heat exchangers and pressure vessels is contained in Bulletins HE and CI which are offered.
4 *Downington Iron Works, Inc.

Instruments & Controls

Feeder, Merchen......Control of other dry or liquid feeders with pneumatic signals. Response to master signals. For more information write Dept. M-56.29.
159 *Wallace & Tiernan

Flow Meters.....Tap-less meters handle naphthalene and heavier aromatics without plugging, fouling or leaking. For complete details write for Bulletin 13-31.
117 *Foxboro Company

Indicator........Digital draw-speed indicator instantly reports precise strip process speeds and speed differentials. For further info, write or contatct Westinghouse.
151 *Westinghouse Electric Corp.

Industrial pH System......The all-new Model J pH system is a compact transistorized analyzer with short, rugged electrodes & accessory mounting assemblies. File 14-52-06.
59 *Beckman Instruments, Inc.

Meters, Liquid.......Helpful metering data available. 28-page technical bulletin lists liquids, helps pick proper sizes and features of meters 2 to 2000 gpm.
157 *Neptune Meter Company

Millivoltmeters........The new 10/20 Series millivoltmeters have all the latest features for indicating, controlling & safety cut-off. Tech. data.
20-21 *Minneapolis-Honeywell

Recorders......The tremendous power of the 90J (pneumatic) and the 700J (electronic) recorders gives you greater accuracy than ever before. Bulletins 98286 & 98335.
45 *Taylor Instruments, Inc.

Rotameter....New Varea-meters measure up to 310 gpm water or 1300 scfm air over range of at least 10 to 1. Magnetic indicators, transmitters, accessories available. Dept. V-8.29.
158 *Wallace & Tiernan

Thermocouples........56-page catalog TC13A contains descriptive information on all products listed and includes engineering information concerning usage and application.
156B Barber-Colman Co.

* From advertisement, this issue

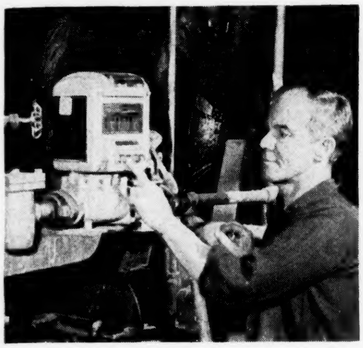
neptune

An advertisement written to help you

Measurement/Control News

prepared by Neptune Meter Company

Birge Wallpapers Use Liquid Meters to Get Fine Color Control



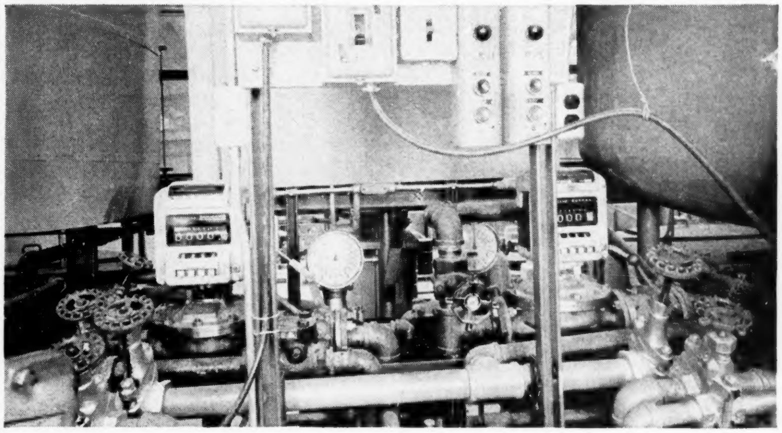
Color control in wallpapers made by The Birge Co., Inc., depends on adding accurate amounts of water to stains and pigments being ground in ball mills. Before changing over to automatic liquid meters, it took 20 minutes to feed 500 lb. of water by calibrated pails. Now it takes only 10 seconds of a man's time . . . the meters do the rest. Call Neptune for information.

How to Select the Right Liquid Meters

How to save time, labor and ingredients *automatically* . . . how to get closer quality control and cost accounting . . . these involve selection of the *right* positive displacement meter with the *right* automatic features. You'll find help in Neptune's "tell how" bulletin. Lists liquids, rates of flow, selector charts, many features such as quantity control and ticket printing. Use coupon at right.

TO REDUCE HAZARDS of corrosive or inflammable liquids, keep them inside the pipes! Meters eliminate dangers of open tanks, dripping gauge sticks, measuring pails, etc. No more accidental contact with liquids or fumes . . . and you get accurate inventory figures, too. Neptune makes a wide range of meters for such applications. Send coupon at right.

10 Meters Formulate "Aerowax," "Black Flag"



"No other method combines such speed, quality control, cleanliness, economy, and morale," says Boyle-Midway

LOS ANGELES—In designing their new plant for "Aerowax" floor wax, "Black Flag" insecticides and other products, Boyle-Midway, Division of American Home Products decided to scrap the gauge stick, and put in ten meters to accurately control all liquid batching. Ranging in size from $\frac{3}{4}$" to 2", the meters proportion alcohol, "Ubatol", shellac, ammonia, isopropylaminoethanol, kerosene, oleic acid, water, and other ingredients.

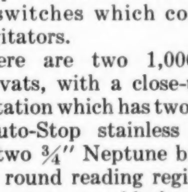
Most of the meters are automatic, eliminating human errors. Simply set them for the correct quantities by pressing keys, open the valves, and they will automatically stop the flow at the right point. Some have explosion-proof switches which control pumps or agitators.

Shown here are two 1,000-gal. "Aerowax" vats, with a close-up of the control station which has two $1\frac{1}{2}$" Neptune Auto-Stop stainless steel meters and two $\frac{3}{4}$" Neptune bronze meters with round reading registers. All are of accurate, trouble-free disc piston type.

You too can benefit by talking over your plans with Neptune.

HELPFUL METERING DATA AVAILABLE

28-pg. technical bulletin lists liquids, helps pick proper sizes and features of meters 2 to 2000 gpm.



NEPTUNE METER COMPANY · Liquid Meter Division

47-25 34th St., Long Island City 1, N.Y.

☐ *Please send me helpful Meter Bulletin 5665*

☐ *Send Meter Specification Guide 5668*

NAME____________ TITLE____________

COMPANY____________

ADDRESS____________ CITY & STATE____________

LITERATURE . . .

Valves......Bulletins are available on rubber-lined iron body gate valves in rising stem, cylinder, & motor operated types as well as on iron body check valves.
107 *Darling Valve & Mfg. Co.

Valves......Sleeveline valves offers a larger sealing area, better adjustment, no pocket to collect liquids & solids. Further information in Bulletin V/14.
109 *The Duiron Co., Inc.

Valves.....Catalog GV111B covers control, hose and rotoflo valves and gives specifications, standards, capacity and size charts and other engineering information.
159A General Kinetics Corp.

Valves......"Pocket Valve Guide" is offered giving brief specs and coverage charts on the new Permaturn valve for versatile application to any fluid control service.
95 *Rockwell Mfg. Co.

Valves, Ball......in a full range of pipe sizes from ⅜" to 14". A wide range of design variations including metal castings of stainless steel, carbon steel, etc.
149 *Rockwood Sprinkler Co.

Valves, Stainless Steel......All the features of these valves are covered in the Stainless Steel Catalog No. 59SS which is available on request.
35 *Jenkins Bros.

Weld Couplets......are easy-to-install fittings for branch connections from pipes, vessels or tanks. Information is contained in Folder SWC-1 which is available.
66 *Henry Vogt Machine Co.

Process Equipment

Agitators......Tank Top agitator gives dependable, rugged agitation at low initial and operating cost. Bulletin 581 gives further information and is available.
124 *Nettco Corp.

Air Separators......offer precise separation and improve screening. Increase 40 to 400 mesh output as much as 300%. For further information Bul .087 is offered.
119 *Sturtevant Mill Co.

Centrifugal......Continuous Solid Bowl type for low cost solid-liquid separations involving moderate volumes, or limited space or extra powerful separating forces. Details.
2 *Bird Machine Co.

Daysolvers......Multiaction turbopeller combines five mixing actions in one for most efficient product dispersion. Write for detailed information.
115a *The J. H. Day Co.

Demineralizers....Two-bed demineralizers designed in capacities of from 300 to 3000 gallons per hour. "Extras" are part of complete package. Catalog #160.
150 *Barnstead Still & Sterilizer Co.

Drying Equipment....Kathabar equipment for toasting or drying. Complete data are available on request for further information on these systems.
156 *Surface Combustion

* From advertisement, this issue

Pipe, Fittings & Valves

Duplex Tubes......More than 125 Duplex combinations are available to solve a wide range of corrosion problems in oil, chemical, power & food processing industries. Bul.
51 *Bridgeport Brass Company

Expansion Joints......Catalog 56 contains complete & comprehensive engineering data for expansion joints from 3 inches to 50 ft. diameter, etc.
41 *Zallea Brothers

Globe Valves......6-page booklet describes valve capable of providing positive bubble-tight shut-off for general industrial and cryogenic service.
158A Walworth Co.

Low Flow Valves......The new Series 1400 valve body gives a choice of actutor-body combinations to match your applications. Details are to be found in Bulletin B803-1.
39 *Minneapolis-Honeywell

Pipe, Glass......Kimax glass pipe is indifferent to the attack of most acids and alkalis and is economical in both installation and maintenance. Information.
57 *Kimble Glass Div. of Owens-Illinois

Pipe, Pyrex....to solve your corrosion problems completely. Available in all standard sizes and fittings. Bulletins are offered for more complete details.
64 *Corning Glass Works

Solenoid Valve......Two-way solenoid controlled coolant valve used to control fluids normally corrosive to non-ferrous materials is described in bulletin 8352.
158B Automatic Switch Co.

Tubing..........In a wide selection of seamless and welded and drawn up to 1" O.D. Available in a wide selection of metals and alloys. Bulletin #13 is offered.
31 *J. Bishop & Co.

Tubing......You can count on welded carbon or stainless steel tubing in critical heat transfer applications. Booklet 8591 is offered for further information.
97 *Welded Steel Tube Institute

Valve......Sampling valves assure perfect sealing by two compressible replaceable Teflon rings. A new catalog page is available for further information.
B125 *Strahman Valves, Inc.

Valve Operators......Complete line of cylinder type valve operators for plug, ball and other rotary valves is described in bulletin 3050 that gives dimensions etc.
158C Ledeen, Inc.

Valves......New globe valve is redesign and conversion of sizes 2" and larger. For details on this and other stainless steel and corrosion resistant valves ask for Bul. #7.
116 *Alloy Steel Products Co.

Valves......DEMI miniature packingless valves offer great porting versatility in isolating, routing & bypass applications. Catalog D-1 is offered for details.
162 *G. W. Dahl Co., Inc.

* From advertisement, this issue

Drying Systems.........Instantaneous Drying Systems process fine wood fibers, filter cakes, sewage sludge and other types of particulate solids. Literature.
118 *Edw. Renneburg & Sons Co.

Filter Assemblies......Bulletin A4 contains general introduction to filters, folowed by 32 data sheets with cross-sectional drawing, rated flow, pressure drop etc.
160A Aircraft Porous Media Inc.

Flo-Screen Filters......Available in 8 graded porosities. Offers complete absence of particle migration and extremely rapid flow rates. See Bulletin MF-G1.
122c *Selas Flotronics

Magnetic Separators......for your wet concentration and magnetic recovery problems. Exclusively the drum type. Details are contained in Catalog 945.
56 *The Jeffrey Mfg. Co.

Micro-Filters......Series C Micro-Filters available in seven grade porosities. Interchange of element grades. Complete facts in Bulletin MF-G1.
122a *Selas Flotronics

Micro-Filters......Series M Micro-Filters offer high mechanical strength plus ability to handle corrosive fluids at high temperatures. Seven grade porosities. Bul. MF-G1.
122b *Selas Flotronics

Mills......3-Roll Mills produce dispersions of the highest possible quality of all types of printing inks, plastisols, paints, etc. Write for detailed information.
115h *The J. H. Day Co.

Mills........Hy-R-Speed Mills grind, homogenize and blend all types of materials, flowing or paste, in one operation. Write for detailed information.
115i *The J. H. Day Co.

Mills......Impact Mills offer improved product quality, elimination of bottleneck, trouble-free efficient operation. Write or phone for info and free lab test service.
123 *Entoleter Inc.

Mixer........Titan Mixers are unsurpassed for processing solid rocket propellants and other materials requiring precision mixing. Write for detailed information.
115d *The J. H. Day Co.

Mixer.........Nauta Mixer offers new three-way action. It features highest mixing accuracy, lowest mixing time, easy addition of liquids, starts under full load, etc. Bulletin.
115f *The J. H. Day Co.

Mixer.......Regal Mixers give unique agitator action which reduces mixing time as much as 50% over other methods. Write for detailed information.
115g *The J. H. Day Co.

Mixers......Mix-Muller saves valuable raw materials and in many cases eliminates secondary processing. Details on a laboratory conducted survey & Handbook on Mulling.
63 *National Engineering Co.

Mixers, Pony........A model for every need with single motion or twin motion mixing action, 1 or 2 speed motors in working capacities from 3 to 125 gal. Bul. 500.
115e *The J. H. Day Co.

* From advertisement, this issue

Mixing Column......CMContactor new multi-stage mixing column handles anything that flows. Combines a mixer and process vessel, designed to fit your needs.
172 *Mixing Equipment Co.

Press, Continuous........Mechanically removes moisture from wet material. Information listed in complete catalog "A." Available free on request.
T160 *Davenport Machine & Foundry Co.

RDC Column......combines many advantages such as high volumetric efficiency, high throughput capacity, elimination of interstage settling, etc. Bul. T-1159.
29 *General American Transp. Corp.

Ribbon Blenders......in a variety of materials......with powerful drives . . . and various types of agitators . . . in capacities that range from 7½ to 3850 gal. Bul. No. 800.
115c *The J. H. Day Co.

Ro-ball Sifters......Superactive ball-cleaning action provides fast, accurate sifting. Single and multiple screen models. Write for detailed information.
115b *The J. H. Day Co.

Pumps, Fans & Compressors

Acid Pumps........with rugges, simple frame construction & packingless design. Long wear parts, few in number, are available in a variety of metal alloys as well as plastic.
171 *A. R. Wilfley & Sons, Inc.

Air Compressors........8-page catalog lists specifications for 43 different compressors and gives complete information on selection and suggested uses.
161A Wayne Pump Co.

Alloy Pump........Model 3139 is constructed of ISO-40, a stainless steel alloy which is highly resistant to corrosion and abrasion. Further information is available.
33c *Goulds Pumps, Inc.

Centrifugal Pumps.......for handling a variety of requirements. A complete line of pumps is available along with various types of compressors.
12-13 *Ingersoll-Rand

Compressors......12-page bulletin 206 describes two-cycle turbocharged gas-engine-driven compressors for pipeline, gas storage and process applications.
161B Clark Bros. Co.

Mised-Flow Pumps.......4-page brochure 211-1 describes pump and includes a cross-section of pump along with dimensions and performance curves plus illustrations.
161C Lawrence Pumps, Inc.

Pump, Chemical Process.....Model 3195 pumps simplify process engineering and cut parts inventories. They offer maximum interchangeability. Bulletin is offered.
33a *Gould Pumps, Inc.

Pump, Vacuum......The new Series H Microvac pump is designed for compactness. Information about this type plus a Vacuum Slide Calculator are offered.
120 *F. J. Stokes Corp.

* From advertisement, this issue

LITERATURE . . .

Pumps......Corrosive, viscous, abrasive or highly compressible fluids over wide temperature range are handled by pumps rated from 5 to 2500 hp. and up to 100,000 psi. Write.
153 *Aldrich Pump Company

Pumps......16-page catalog 500 describes and illustrate complete line of "U" type pumps for continuous metering and proportioning of small volume flows.
162A Hills-McCanna Co.

Pumps......Triplex pumps save packing failure at high pressures. Available in 120 different cylinder designs to meet every product problem.
83 *Manton Gaulin Mfg. Co.

Pumps........Bulletin 47740 describes complete line of electrohydraulic servo controlled pumps and system components and details how they work and where they are applied.
162B The Oilgear Co.

Pumps......Complete pump line, qualified recommendations, simple design and rugged construction, installation and service plus experience. Write today for information.
161 *Weinman Pump Mfg. Co.

Pumps and Motors......5,000 psi piston pumps and motors useable in a wide range of power transmission applications and featuring a variety of controls described in bulletin.
162C Vickers Inc.

Services & Miscellaneous

Control Valve Noise........Technical manual TM-9 presents problem of noise emitted by control valves and explains how sonic vibration can be damaging to equipment.
162D Fisher Governor Co.

Corrosion.......60-page booklet "The Role of Molybdenum and Copper in Corrosion Resistant Steels and Alloys" contains numerous charts, graphs and tables.
162E Climax Molybdenum Co.

Dialysis......A separation method utilizing diffusion as its driving force is discussed in technical paper T-186 "Dialysis for Acid Recovery".
162F Graver Conditioning Co.

Fire-Fighting Products....Foam liquid binds large volumes of air & water into an effective low cost extinguishing agent for fighting any type of fire. Inform.
23 *Rockwood Sprinkler Co.

Maintenance Record Cards......Easy-to-use cards for keeping pump maintenance records are offered. Help in ordering new parts, scheduling lubrication, etc.
33b *Gould Pumps, Inc.

Profession Advancement.......Booklet E-7 is available on request as one of a series on personal and professional advancement which has been prepared for engineers.
114 *Western Supply Co.

Safety Equipment......28-page catalog describes latest types of emergency deluge showers, aerated eye and face wash fixtures and water spray accessories.
162G Speakman Co.

* From advertisement, this issue

Employment Opportunities

CE's nation-wide coverage brings you tips and information on current opportunities in job functions throughout the chemical process industries.

▶ **Displayed Rates**—$62.00 per inch for all ads except on a contract basis: contract rates on request. An advertising inch is measured 7/8 in. vertically on a column; 3 columns, 30 in. per page. Subject to the usual agency commission.

▶ **Undisplayed Rates**—$2.40 per line, 3 lines minimum. To figure advance payment count 5 average words as a line; box number counts as 1 line. 10% discount if full payment is made in advance for 4 consecutive insertions. Not subject to agency commission.

CHEMICAL ENGINEERS PROCESS IMPROVEMENT

The Chemstrand Corporation—a leader in the field of chemical textile fibers—is seeking chemical engineers for assignments involving process and product improvement. Such assignments include process analysis and evaluation, machine and equipment modification, as well as technical assistance on day to day process problems. Current openings, which offer unusual opportunities for advancement, are in the Pensacola, Florida and Greenwood, South Carolina nylon plants and in the Acrilan® Plant and Chemstrand Technical Center located in Decatur, Alabama.

These progressive southern cities offer a pleasant climate, attractive living, cultural and recreational opportunities.

Send resume of academic training, experience and salary history in confidence to: Manager, Employment-Recruitment, Dept. N-3, The Chemstrand Corporation, 350 Fifth Avenue, New York 1, New York.

CHEMSTRAND
CORPORATION
350 FIFTH AVENUE, NEW YORK 1, NEW YORK

Allied Chemical

Chemical Engineers

Process and project engineers for expanding Central Engineering Department engaged in process development, equipment and plant design, economic evaluations.

Requirements

BS or MS in Chemical Engineering with 2-10 years experience in inorganic, heavy organic or electrolytic processes preferred.

Location in attractive area of Central New York State.

Send detailed resume to

Personnel Supervisor
Solvay Process Division
Allied Chemical Corporation
P.O. Box 271
Syracuse 1, New York

BECHTEL

San Francisco

Bechtel Corporation offers immediate employment opportunities to chemical engineers experienced in process design of major petrochemical, refinery, or similar processing units.

Liberal transportation and relocation allowances for you and your family. Please send resume of experience, including present and required salary, to W. A. Anderson, Technical Recruiting.

Bechtel Corporation
220 Montgomery Street
San Francisco, Calif.

ENGINEERS

SENIOR PROCESS
SENIOR PROJECT

McKEE offers exceptional career opportunities to men qualified by experience with engineering contractors engaged in the design and construction of petroleum, chemical and petrochemical plants.

Send detailed resume to:
G. VICTOR HOPKINS

ARTHUR G. McKEE & CO.
2300 Chester Ave. Cleveland 1, Ohio

CHEMICAL ENGINEER

McKee has a challenging position in Cleveland for a chemical engineer in the ammonia field. Candidate should have at least 10 years of diversified chemical engineering experience, with several years in the design of ammonia plants.

Send detailed resume to
G. Victor Hopkins

ARTHUR G. McKEE & CO.
2300 Chester Ave. Cleveland 1, Ohio

WANTED—ENGINEER

experienced in Ore Beneficiation Plant layout design and capital cost estimating. Excellent opportunity. Location: Northern Minnesota. Reply

P-7869, Chemical Engineering
645 N. Michigan Ave., Chicago 11, Ill.

SALES ENGINEER
for LOS ANGELES Area

to sell Heat Exchangers, Steam Generators, Tube-Ice Machines. Must be graduate engineer with experience in one of these fields. Write to Dept. 24A

HENRY VOGT MACHINE CO
P. O. Box 1918 Louisville 1, Kentucky

PROFESSIONAL SERVICES

CARL DEMRICK

Technical Translations

Send for Circular
53 So. Broadway Yonkers, N. Y.

Equipment Searchlight

CE's Searchlight spots the big bargains in used, resale and rented equipment. Check this issue's listings—most complete in the field—for items you need now.

▶ **Coverage** — National. Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

▶ **Rates**—$25.00 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.

▶ **Closing Date** — January 22nd issue closes December 29th. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

HOW to LOCATE EQUIPMENT

without cost or obligation

This service is aimed at helping you to locate Surplus New or Used equipment, if you do not find your present requirements advertised in this section.

Send us the specifications of the equipment wanted and you will receive an immediate reply with full details.

EQUIPMENT FINDERS BUREAU
SS-6663, Chemical Engineering
Class. Adv. Div., P. O. Box 12, N. Y. 36, N. Y.

CIRCLE G ON READER SERVICE CARD

BEST VALUES

Evaporators: Four St.St. Buflovak dbl. eff. 608-708-845-1125 sq. ft. each. Long tubes.
Evaporators: Five St.St. sgl. eff. 94-150-216-450-800 sq. ft. each. Long tubes.
Vacuum Pan, Royers 6 ft. with make up tanks. All St.St.
Votator: Girdler three 4" x 46" stainless cylinders and rotors, ammonia chilling system.
Vacuum Dryer: Stokes 2" x 6" Rotary, jacketed, St.St. With drive, condenser, receiver.
Dryers: Double Drum, 42 x 90; 32 x 120 Buflovak.
Dryers: Double Drum, 42 x 120; 36 x 84 American.
Dryer: Proctor & Schwartz, 12' wide multi-pass St.St. conveyor.
Dryer: Raymond Flash Dryer and Cooler with cyclones, furnace, ducts, etc. 20,000#/hr. Never used.
Twin Shell Blenders: P.K. 5 cu. ft. St.St.; P.K. 30 cu. ft. steel with intensifier.
Centrifuges: Tolhurst 40" and 26" Suspended. Perf.
Centrifuge, Sharples Model DH2, Nozzle jector. St.St.
TANKS: St.St.—(20 in stock) 4000 gal. to 500 gal. Vertical and horizontal. Atmospheric and Vacuum type. Some with coils.
Kettles: (2) 600 gal. agitated St.St.; with 15 P.S.I. steel jacket.
Glass Lined Kettle: 750 gal. Pfaudler, 50 PSI shell, 90 PSI jacket; agitator.
Mix Muller: Simpson, Size #2, 1000 lb. St.St. 15 H.P. drive.

BEST EQUIPMENT COMPANY
1737 W. HOWARD ST. CHICAGO 26, ILL.
AMbassador 2-1452

CIRCLE A ON READER SERVICE CARD

OVER 5,000 MACHINES IN STOCK

FOR EVERY INDUSTRY AND PURPOSE

- Wrappers
- Packaging machines
- Cartoning machines
- Fillers
- Labelers
- Filter presses
- Roller mills
- Mixers
- Pulverizers
- Grinders
- Dryers
- Sifters
- Cappers
- Tablet machines

TELL US YOUR REQUIREMENTS

Complete Details And Our Special Low Bargain Prices Available On Request

UNION STANDARD EQUIPMENT CO.
318-322 Lafayette St., New York 12, N. Y.
Phone: Canal 6-5333-4-5-6

CIRCLE C ON READER SERVICE CARD

WANTED

Pressure vessel to handle live steam at 60 psi. Used for rubber vulcanizing. Must be ASME Coded vessel for use in New Jersey. Door can be either bolted or quick-opening connection. Size 60" I. D. or larger, length 2 feet minimum, 10 feet maximum. Address Box

W-7941 Chemical Engineering
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

CIRCLE H ON READER SERVICE CARD

WATER UNLIMITED!

Strikes? Unknown. Location?—Fort Madison, Iowa. Plant—33,000 feet—modern—one floor—Sprinklers. Office? — modern, air conditioned. PRICE? — COULDN'T BE MATCHED! FINDERS FEE PAID.

C. A. BUCKSTEN
209 So. La Salle Street Chicago 4, Ill.

CIRCLE J ON READER SERVICE CARD

FOR SALE
WYSSMONT TURBO DRYERS

5—Rotating Tray type, Model No. VTL-24, Tray, with tray and fan drives. Includes externally mounted 4-coil Steam Heat Exchanger, and motorized Blower to heat air to Dryer. Further information and price on request.

DALTON SUPPLY CO.
2181 E. Huntingdon St. Phila., Pa.

CIRCLE D ON READER SERVICE CARD

BOILERS

TURBO-GENERATORS • DIESELS
PUMPS • FANS • BURNERS • HEATERS

Large Selection . . . New and Used

EXPERIENCED ENGINEERS TO ASSIST YOU

WABASH POWER •EXPORT•

WABASH
POWER EQUIPMENT CO.
PHONE IN 3-0303
3300 W. PATTERSON AVE.
CHICAGO 45, ILL.

CIRCLE K ON READER SERVICE CARD

SPECIAL BARGAIN OPPORTUNITIES

3000 KW, 3600 RPM, 80% P.F., 3/60/13,800 V., UNUSED Allis Chalmers non-condensing automatic extraction steam turbine generator unit, 425 PSIG, 700-750°FTT, 170 PSIG automatic extraction, 60 PSIG back pressure.

1500 KW, 3600 RPM, 80% P.F., 3/60/2300 V., General Electric non-condensing steam turbine generator unit, 375 PSIG, 650-700°FTT, 85-125 PSIG back pressure.

NEW, UNUSED Babcock & Wilcox coal pulverizer, Type E-56, equipped with American Blower Corporation air fan, 15,000 CFM capacity with motor drive. Complete coal pulverizer installation with blower air fans, attached and unattached structural parts, capacity 14,600# per hr.

This excellent equipment is offered at a fraction of replacement cost.

Utilities Machinery Corporation
912 National City E. Sixth Bldg.
Cleveland 14, Ohio Telephone CH-1-0210

CIRCLE B ON READER SERVICE CARD

Pfaudler 10 gal. Glass Lined Kettle
Hersey 5'x26' Rotary S.S. Dryer
Buffalo 32"x90" Double Drum Dryer
Day Hy-R Speed Mill 20 HP XP

SEND FOR LISTINGS

STEIN EQUIPMENT CO.
107—8th Street Sterling 8-1944 Brooklyn 15, N. Y.

CIRCLE E ON READER SERVICE CARD

JANUARY SPECIALS

Stokes vac. shelf Dryer 2 shelf 40" x 42"
Buflovak 4" x 8" Lab. SS double drum Dryer
Day #40 Imperial jkt. Mixer, 150 gal.w'k,40hp exp.
Abbe 5'x6' jktd. Ball Mill, chrome mang. steel
Pfaudler 1500 gal. glass lined Tank, closed top
Simpson 24" Lab. SS Mix Muller, 1½ HP motor
Gruendler #3 Hammermill, Whirlbeater, 22"
2 Fitz Mills Model D, 5 HP motors
Ribbon Blenders, Steel & SS, all sizes, new & Used

WHAT HAVE YOU FOR SALE OR TRADE? YOU CAN BANK ON

EQUIPMENT CLEARING HOUSE, INC.
111 33 Street, Brooklyn 32, N. Y.
SOuth 8-4451—4452—8782

CIRCLE F ON READER SERVICE CARD

2—New 5000 Gallon Pressure Vessels

Mfgd. by Babcock & Wilcox. ASME rated. 1750# oper. press.; 3572# press. tested. 650 deg. F max. temp.; Weight 80,500# Blt. 1952. Size 23' L x 53" I.D. With piping, valves, fittings, etc.
Pressure pumps—all sizes and kinds available.

EVEREADY—Box 1780—Bridgeport, Conn.
Ed McCallum ED. 4-9471

CIRCLE L ON READER SERVICE CARD

YOUR $ BUYS MORE

DAY STAINLESS MOGUL MIXER
In Our Stock

200 gallon working capacity. Heavy double nobben cored agitator blades. Jacketed for 125 PSI pressure, vac cover code constructed. 75 HP expl proof motor and drive. Purchased new 1959. Original cost $45,000.00.

SAVE MANY THOUSANDS

MACHINERY AND EQUIPMENT CO., INC.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE M ON READER SERVICE CARD

LIQUIDATIONS

CLEVELAND, OHIO

1—Raymond #73612 Super High Side 6-Roll Mill, with whizzer, cyclone, piping and motors.
1—Raymond #5047 High Side 4-Roll Mill, with whizzer, cyclone and piping.
1—#1 Raymond Impact Mill, with whizzer, cyclone and piping.
1—Kilby Nickel Single Effect Force Feed Evaporator, 1200 sq. ft.
2—Oliver 5'3" x 4' Nickel Clad Rotary Vacuum Filters.
4—Feinc 8' x 12' Rotary Vacuum Steel Filters, string discharge.
2—6'6" dia. x 60' Rotary Dryers.
1—5½' x 4½' x 50' Rotary Dryer.
7—Dorr 80' and 40' thickeners.
2—Tyler Hummer 3' x 10' Double Deck Screens.
2—Fuller Kinyon Pumps H6.
1—Link-Belt 24" x 90' Belt Conveyor.
5—Nickel Centrif. Pumps, 2", 3".

JUST PURCHASED

NEW—1957—1959

4—Glascote 1500 gal. jacketed, agitated Reactors, 100# Jacket, 100# Int.
3—Glascote 500 gal. jacketed, agitated Reactors, 75# Jacket, 75# Int.
1—Oliver 5'3" x 4' Rotary Vacuum Precoat Combination Filter, 304 SS.
2—Oliver 3' x 2', 3' x 6' Rotary Vacuum Filter, 304 SS.
3—Sharples DH2 Nozljectors, 316 SS, 20 HP.
1—Baker Perkins S15 Ter Meer Continuous Centrifuge, 304 SS.
6—316 Stainless steel Bubble Cap Columns, 24", 30", 42", 48", 54", 60" dia.
1—Dowtherm Boiler 12,000,000 BTU.

CENTRIFUGES

2—Bird 18" x 28" Solid Bowl Continuous 304 S.S.
1—Bird 40" x 60" Solid Bowl Continuous 316 S.S. UNUSED.
5—Sharples C-20 and C-27 Super-D-Hydrators 316 S.S.
1—DeLaval AC-VO Continuous S.S. 20 HP.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
2—Sharples #16, 304 S.S., 3 HP motor.
1—Tolhurst 40" 347 S.S. imperforate basket 15 HP. UNUSED.
1—Bird 40" Suspended imperforate basket 40/10 HP.

BRILL FOR VALUES

REACTORS—EVAPS—CONDS—COLUMNS

4—Glascote 500 gal. glass lined, Jacketed Reactors.
1—Pfaudler 125 gal. 304 S.S. Jkt. Agit. Reactor, 150# int., 125# jacket.
5—Pfaudler 300, 200, 100 and 50 gal. glass lined jacketed, agitated Reactors.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—8650 sq. ft. NICKEL double effect forced Circulation Evaporator, UNUSED.
1—3000 sq. ft. O. G. Kelly 309 S.S. forced feed Evaporator, UNUSED.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—300 sq. ft. Swenson 347 S.S. Single Effect Evaporator.
1—250 sq. ft. Buflovak 304 S.S. Single Effect Evaporator.
10—Stainless Heat Exchangers; 910, 536, 370, 250, 131, 70 sq. ft.
5—Pfaudler 26 sq. ft. glass lined Condensers.
1—4'6" x 46' 316 S.S. Clad Column, 250 PSI.
8—3' x 20', 30" x 19' 347 S.S. Packed Columns.
1—24" x 35' 304 S.S. Bubble Cap Column.

FILTERS

2—Niagara 370 sq. ft. Vert. 304 S.S.
1—Niagara 110 sq. ft. Vert. 316 S.S.
1—Niagara 92 sq. ft. Vert. Jkt. 316 S.S.
1—#10 Sweetland, 36 leaves 3" centers.
1—#5 Sweetland 304 S.S., 120 sq. ft.
1—Sperry 30" C.I. Filter Press, 27 chambers.
1—Oliver 6' dia. Horizontal 316 S.S.
1—Oliver 4' dia. Monel Horizontal.
1—U. S. 200 sq. ft. 304 S.S. Auto-Jet.
1—Hercules 400 sq. ft. 304 S.S. Pressure.
3—Oliver Precoat 5' x 6', 5' x 10', 8' x 10'.
1—Oliver 5'3" x 8' Steel Rotary Vac Housing.
1—Feinc 3' x 1' 316 S.S. Rotary Vac.

DRYERS

1—Buflovak Vacuum Shelf, 17-60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum complete.
3—American 42" x 120" Atmospheric Double Drum Dryer, complete.
1—Buflovak 32" x 90" Atmos. Twin Drum.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 48" x 28" C.I. Single Drum Flaker.
1—Buflovak 3' x 10' Rotary Vacuum.
6—Louisville Rotary Steam Tube, 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel Lined Rotary.
3—Rotary Dryers 6' x 50', 7' x 80', 8' x 80'.
1—Link Belt 6'4" x 24" Roto Louvre 316 S.S.
1—Link Belt 3'10" x 16' Roto Louvre.
1—4' dia. 304 S.S. Spray Dryer.
1—Wyssmont, 304 S.S. 6'2" dia.

MIXERS—MILLS

1—Sturtevant 75 cu. ft. 304 S.S. Rotary Batch Blender 20 HP.
1—Abbe 110 gal. 304 S.S. Jacketed Agitated Vacuum Dispersall Mixer.
2—Baker Perkins 150 and 100 gal. Jacketed double arm Sigma blades.
1—Baker Perkins 50 gal. jacketed.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
1—Steel jacketed Powder Mixer, 225 cu. ft.
1—Day 215 cu. ft. Jumbo Powder Mixer 316 S.S., 30 HP motor.
1—Day 120 cu. ft. Jumbo Powder Mixer, 25 HP motor.
1—45" dia. Lancaster Mixer 7½ HP.
3—Hardinge 6' x 36", 5' x 22" and 3' x 24", steel lined conical Ball Mills.
2—Mikro Pulverizers, 2TH and 1SI.

TANKS

25—500 to 3500 gal. Vertical 304 S.S. Tanks opened and closed, some agitated.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2000 gal. Horizontal 304 S.S. Tank 5' x 12'.
1—2500 gal. Vertical 304 S.S. Tank 8' x 7'.
1—10,000 gal. Rubber Lined Tank 10' x 17'6".
1—5500 gal. 316 S.S. Clad Pressure Tank 250 PSI.
2—3000 gal. Aluminum Tanks, 7' x 11'.
5—25,000 gal. Aluminum Storage Tanks.

MISCELLANEOUS

3—Kinney Vacuum Pumps, 1000 cfm, 10 microns, 15 HP.
3—Hardinge 6' x 36", 5' x 22" steel lined conical Ball Mills.
1—Sturtevant 6' dia. Air Separator 10 HP.
1—Komarek Greaves Briquetting Press 3½" face rolls.
3—Mikro Pulverizers, 1SH, 1SI and Bantam.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—Tyler Hummer 3' x 10' Double Deck Screens.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
6—Nash H6, H5, L5 Vacuum Pumps.
3—Nash H6, L3 347 S.S. Vacuum Pumps.
2—Stokes Rotary Tablet Machines DD2-DDS2.

Partial List of Values—Send for Complete Circular

BRILL EQUIPMENT COMPANY

35-61 JABEZ ST., NEWARK 5, N. J. Tel: MArket 3-7420—N. Y. Tel: RE 2-0820
TEXAS OFFICE: 4101 San Jacinto St., Houston 4, Texas—Tel: JAckson 6-1351

CIRCLE N ON READER SERVICE CARD

SEASON'S GREETINGS from the ENTIRE
FIRST MACHINERY and FALCON STAFF

SEND FOR FMC'S NEW 1962 COMPACT CATALOG CHEMICAL EQUIPMENT

AFTER YOU TAKE INVENTORY * SEND US YOUR LIST OF SURPLUS EQUIPMENT—OPEN TO BUY COMPLETE DEPTS.

Vacuum Shelf Dryers by Devine and Buffalo up to 86" x 78"	New FALCON Double Ribbon Blenders in Stainless or Steel; all sizes stocked
Fitzpatrick Comminutating Machines; Models C, D, and K in Stainless	Bird Continuous Centrifugal Filter in Stainless, 18" x 28"
Sharples C 27 Super-D-Hydrator in Type 316 Stainless; 40 HP	Buflovac Rotary Vacuum Dryer 3'x7'6" in Type 316 Stainless
Plastic & Rubber Equipment; Mills, Calenders, Extruders, Pelletizers	Rotex and Roball Sifters-Screens Single & Multiple Deck to 120"
Baker Perkins Double Arm Jacketed Mixers from 2 Gal. to 300 Gal.	Stainless Steel Packed Columns; 8" x 10' and 12" x 15'
Stainless Steel Reactors from 60 Gal. to 2000 Gal. Jktd. Agtd.	Shriver and Sperry Ni-Resist and Stainless Filter Presses to 30"
Porcelain Lined and Buhrstone Pebble Mills up to 8' x 8'	A. O. Smith Pressure Tanks, Stainless Lined 10' x 18' with agitators
Mikro Pulverizers, all types in size from Bantam to No. 4's	Buffalo Stainless Thermo-Compression Evaporator, complete
Nickel Clad Reactor 7' x 11'6"; Jacketed-Agitated; Manhole Top	S. S. Lined Rotary Dryer 50" x 20', Counter Current with Accessories
Oliver Pre-Coat Rotary Vacuum Filters; Acid Resistant to 8' x 10'	Link Belt Roto Louvre Dryer Model No. 502-20 complete

SEND FOR SPECIAL BULLETINS ON LIQUIDATIONS
CINCINNATI-TOMS RIVER CHEMICAL CO. IN CINCINNATI
CEMENT MILL MACHINERY IN TENNESSEE

FIRST MACHINERY CORP.

209-289 TENTH STREET, BROOKLYN 15, N. Y.

FMC Pays MORE For Your Surplus

PARKING ON THE PREMISES
Phone: STerling 8-4672
Cable Address: "EFFEMCY"

FMC

CIRCLE O ON READER SERVICE CARD

2 Autoclaves, Jac.-5' x 18'
Baker Perkins—100 gal—50 HP, S.S.-2 arm jac.-vacuum hdr. tilt
Aluminum Evaporator Calandria type—never used—1300 sq. ft. tube area
Nickel Heat Exchanger 250 sq. ft.
2 Blenders-Conical S.S.-24", 30"
1 Steel Blender—70 Cu. ft.
Distillation Unit S.S. type 316-1200 gal. per hr.
Hydraulic Pumps & Motors

MACHINECRAFT CORPORATION
800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE P ON READER SERVICE CARD

BUY ON TERMS!

2—PFAUDLER REACTORS

Model R high pressure 750 gallon, glass lined Reactors. With turbine agitators, adjustable baffles and drives. Perfect glass.

Immediately Available

ME
MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE Q ON READER SERVICE CARD

FOR SALE

Due to change in methods, have available—one Niagara Batch Miser size 18-18-S Horizontal Plate Filter complete with 18 plates, hand wheels, new spacer to replace nine plates for small Batch Filtering, 2 years old. Also one Shriver 24" x 24" 4 Eye Filter Press 18 plates and frames with Hydrokloser and metal screens. Both in perfect condition. Best offer. No Dealers. Write or Call

FARNOW, INC.
4-83 48th Ave., Long Island City, N. Y. ST 6-1144

CIRCLE AA ON READER SERVICE CARD

Mr. Used Equipment Dealer:

When you advertise in the Searchlight Section . . . You have hired your most persuasive salesman:

He's efficient . . . He thrives on long hours . . . His territory is the entire nation . . . and overseas . . . He doesn't see buyers of used and new surplus equipment: They see him —regularly. They depend on him.

He is Searchlight—The section of this publication where wise dealers advertise and list their stocks for sale.

SEARCHLIGHT SECTION

Classified Advertising Div.
Post Office Box 12 New York 36, N. Y.

TO ALL OUR FRIENDS IN THE CHEMICAL-PROCESS INDUSTRIES—

Seasons Greetings — Happy New Year!

DRYERS — KILNS

1—Buflovak 2' x 7'-10" T304 SS rot. vac. dryer, ASME, jktd., Agit.
2—Buflovak 42" x 120" double drum dryers, ASME 160# WP.
1—American 42" x 120" dbl. drum.
1—Buflovak 42" x 90" dbl. drum.
2—American 36" x 84" dbl. drum.
1—Buflovak 32" x 52" dbl. drum.
1—American 36" x 84" double drum dryer, ASME, VACUUM.
1—Buflovak 5' x 12', single drum dryer, Vacuum, UNUSED.
1—Buflovak 6" x 8" dbl. drum.
3—Stokes 195 sq. ft. vac. shelf dryers.
1—Nerco-Niro stainless spray dryer.
1—10' x 11' x 175' Vulcan kiln.
6—10' x 100' rotary dryers, ⅝" welded shell, complete.
2—B. & Snow 8'-6" x 70' rotary dryers, ⅝" welded shell, late model.
2—8' x 125' rotary kilns, ⅝" shell.
1—7'6" x 62" rotary kiln, ½".
1—6' x 150' rotary kiln, ⅝" welded.
1—Louisville 5' x 30' steam-tube.
2—Louisville 4'-6" x 25' rotary steam-tube dryers, welded.
1—Bartlett & Snow 3' x 15' rotary dryer, Everdur metal shell.
1—3' x 23' rotary, ¼" welded.

STAINLESS STEEL TANKS

(T304 UNLESS NOTED)

3—20,000 gal., 14' x 15', T316LC, cone bottom, ⅜".
2—13,000 gal. 11'10" x 15'7".
1—12,000 gal 9'-6" x 22', T304 SS, horiz., dished—UNUSED.
2—5700 gal. horiz., 6'-4" x 24', UNUSED.
2—4500 gal. vert., 8' x 12', UNUSED.
5—3650 gal. 10' x 7', vert., open.
1—3350 gal., 8'x8'6", agit., 50 psi.
1—3300 gal. 6' x 14'-6", vert.
1—3250 gal., 6' x 15', T316.
7—3000 gal., 8' x 8', T316 SS, Vert.
2—3000 gal. 8' x 8' vert.—UNUSED.
1—2800 gal., 5' x 18', dished.
2—2600 gal., 7' x 8', T316 dished.
1—2250 gal., 8' x 6', T316, coils
5—2100 gal., 8' x 5'6", dished.
1—2100 gal., 6' x 9', T316, cone.
12—1750 gal., hoppers, 4'-5" x 7'-4" x 9'-2".
4—1350 gal., 4' x 14', T347, dished, ASME 60 psi coils.
5—1350 gal., 7' x 4'-6", T321.
1—1300 gal., 6' x 6', ⅜", dished.
3—1100 gal., 4' x 11', T347, 60 psi.
3—1000 gal., 4'-6" x 8'-6", dished.
3—850 gal., 4' x 9', ⅜", dished.
1—800 gal., 5'x5'6", ¼", dished.
3—750 gal., 5' x 5', 3/16", dished.
6—685 gal., 3' x 13', T316, coils.
3—300 gal., 4' x 3', T347, 60 psi.

KETTLES—REACTORS

1—2000 gal. Glascote blue G/L reactor.
40—1400 gal. Pfaudler blue G/L jkt. kettles, Agit., baffles.
3—1350 gal. T347 SS kettles, open top.
13—1250 gal. Pfaudler blue G/L jkt. reactors, Agit.
1—1200 gal. Artisan T304 SS reactor, vac. int., 100 psi jkt., Agit.
1—1000 gal. T316 SS jacketed reactor, ASME, UNUSED.
1—1000 gal. Dopp cast iron kettle, 125# jacket, 15# int., Agit.
1—750 gal. Graver T304 SS jkt. fermenter, ASME Agit.
1—750 gal. Pfaudler glassed jkt. kettle.
3—500 gal. Pfaudler "R" glassed jacketed reactors, Agit.
50—600 gal. Pfaudler Stainless jacketed kettles, open.
1—500 gal. T316 SS jacketed reactor.
2—500 gal. T304 SS reactors, jacketed, ASME, Vacuum—Unused.
6—465 gal. T304L SS reactors, jacketed, 150# int., 175# jkt.
1—300 gal. T316 SS jkt. kettle, Agit.
1—300 gal. T304 SS jacketed reactor, vac. ASME—UNUSED.
1—300 gal. Pfaudler blue G/L reactor, Agit., jkt., ASME.
2—200 gal. T304 SS jkt. reactors, ASME, UNUSED.
1—175 gal. T304 SS jkt. reactor.
1—150 gal. Pfaudler "P" glassed reactor, jacketed, Agit.
2—100 gal. UNUSED T304 SS jacketed reactors, vacuum, ASME.
1—80 gal. T347 SS autoclave, 350 psi WP, 100 psi jkt., Agit.

MIXERS—MILLS

25—Baker-Perkins 200 gal. jkt. sigma-blade Dbl. Arm Mixers.
1—Baker-Perkins 100 gal. dispersion mixer, #15-UUMM, 100 HP drive, jacket, comp. cover, motorized tilt.
1—Baker-Perkins 100 gal. disp. mixer, T347 SS, jkt.
2—145 cu. ft. horiz. ribbon mixers.
1—Sturtevant 75 cu. ft. blender, T304 SS.
1—Worthington 70 cu. ft. rotary blender.
12—Abbe Eng. 6' x 8' pebble mills.
3—Hardinge conical pebble mills: 8' x 48", 7' x 36".
1—Marcy #64½ ball mill, 100 HP.
1—Allis-Chalmers 6' x 12' rod mill.
1—Bonnot 5'x10' ball-rod mill, 75 HP.
1—Raymond 66", 6-roller hi-side mill.
1—Raymond 50", 5-roller hi-side mill.
1—Fitzpatrick #1 Stainless comminutor.
3—Forster #8 hammermills, 100 HP.

EVAP.—EXCHANGERS

7—4050 sq. ft. calandria type evap., copper tubes, cast iron shell.
1—1250 sq. ft. Mojonnier dbl.-effect Stainless Sanitary evaporator.
3—Buflovak double-effect stainless evap., vert. long-tube, 840, 710, 588 sq. ft.
1—630 sq. ft. Struthers-Wells T316 SS Calandria evap.
1—320 sq. ft. steel reboiler.
1—250 sq. ft. Buflovak T304 SS, single effect recompression evap.
1—118 sq. ft. Stokes T316 SS still.
1—36" dia. x 6 plate T316 SS column.
2—Vulcan T316 SS 10 plate bubble cap columns: 110", 60" dia.
6—30" x 19' T347 SS packed columns.
8—24" x 16' Duriron packed columns.
1—24" x 33' Duriron & SS column.
1—1960 sq. ft. T316 SS exchanger, remov. bundle, ASME 75# WP.
1—1450 sq. ft. T316 SS condenser.
5—1400 sq. ft. T316 SS gas converters.
1—900 sq. ft. T304 SS exchanger.
3—800 sq. ft. T316 SS condensers.
1—730 sq. ft. T316 SS exchanger.
6—691 sq. ft. copper dbl. pipe cooler.
1—510 sq. ft. T316 SS condenser.
8—400 sq. ft. T304 SS pipe coolers.
12—Amer. Heat Reclaiming T316L SS spiral exchangers: 162, 73 sq. ft.
15—75 sq. ft. nickel pipe coolers.
30—T316 SS heat exchangers & condensers: 425, 400, 290, 277, 200, 165, 150, 142, 105, 73, 54 sq. ft.
50—Duriron exchangers & condensers.
5—Pfaudler glassed thimble condensers: 62, 47, 15 sq. ft.

STAINLESS PUMPS

Aldrich T316 SS 3-cylinder piston pumps: 3⅛" x 5", 2⅝" x 3", 1½" x 2".
Worthington Worthite Cent. Pumps; 4" x 3", 3" x 2", 2" x 1½", 1½" x 1", w/motors.
LaBour 2" 316 SS self-priming cent. pumps w/motors.
Aurora 1½" SS sump pumps

STAINLESS PIPE & VALVES

50,000'—T304 SS pipe, sch. 10 & 40, 1" to 6".
20,000'—T304 SS vapor pipe, to 24".
10,000 —T304 & T316 SS flanged valves, to 8".

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE R ON READER SERVICE CARD

FOR "IMPOSSIBLE" BUDGETS

Hersey Dryer, 7' x 30' Rotary hot air. Welded shell. 15 HP motor

Apron Dryer, 36" wide SS belt 98' long. 2,000,000 BTU. Natural Gas Burner

St. Regis Fillers, 1—Model 101 FS, single spout and 107 FC 3 Spout

Patterson-Kelly Twin Shell Blender, 1 cu. ft. ½ HP Ex Proof Motor (2)

Raymond 16' Whizzer Air Separator, and Sturtevant 16' Whirlwind Separator

Foster-Wheeler unused Karbate Heat Exchanger. 59 sq. ft.

Sweco 48" Separators; 1—4 deck and 1—2 deck. Each complete

1—Raymond Model 5048 high side Mill w/Whizzer Separator. TEFC mtrs New 1951

For immediate quote, write or phone collect—GA 1-1380

MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. - San Francisco 7, California

CIRCLE S ON READER SERVICE CARD

LOCOMOTIVE—RR CARS & CRANES

9 Gen. Elec. 20, 25, 45, 65, 70, 80, 100, 125 Ton
25-Ton Industrial Brownhoist 60' Boom Crane
200—50 Ton Box 300—70 Ton Gondola Cars
300—1½, 5, 20 & 30 yd Dump Cars

PLANT EQUIPMENT

2—Wemco 2M-HMS Plants
12" Traylor Gyratory Crusher
No. 1—Sturtevant Hammer Bar Mill
No. 2 Robins Vertical Cone Crusher
24" x 24" Jeffrey Single Roll Crusher
No. 1 Sturtevant Rotary Fine Reduction Crusher
5' x 8' & 4½' x 9' KVS Air Swept Ball Type Mills
Ball Mills: No. 56, 5' x 5', 6' x 4', & 7' x 22'
Hardinge Mills 3' x 8', 5' x 22" & 8' x 22"
24 FC Telsmith Gyrasphere Crusher
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 9" x 24", 10" x 30', 13" x 24", 14" x 28", 18" x 36", 30" x 36", 48" x 60", 66" x 84"
36" x 12' & 48" x 10' Telsmith Apron Feeders
Crushers, Fine Reduction: 22", 2', 3', 4', 5½' x 7'
636 & 436 Allis Chalmers Hydrocone Crushers
Crushers Roll: 24" x 14", 30" x 14", 40" x 16"
5' x 30' Ruggles Coles Double Shell Rotary Dryer Complete
Rotary Dryers: 5' x 30', 6' x 50', 6' x 70' & 8' x 80'
Rotary Kilns: 6' x 70', 7' x 110' & 9' x 160'
2—13" x 120" Buflovak Atmos. Double Drum Dryer
Roto Louvre #207-10 Type 316 S. S. Link Belt
150—1½, 2 & 4 yd. & 30 yd Dump Cars
6—36" x 32" Dings Magnetic Head Pulleys
690, 2200', 3068' & 3600-7500' IR. Compressors
4100 CFM Sly Dust Collector

WANT BUY DRYERS—KILNS—CRUSHERS

R. C. Stanhope, Inc., 60 E. 42 St., N. Y. 17, N.Y.
Tel. MU 2-3075 or MU 2-1898

CIRCLE X ON READER SERVICE CARD

LIQUIDATIONS

Niagara Falls, N. Y. and Everett, Mass.

EQUIPMENT OFFERINGS

Baker Perkins 100 gallon MIXER jktd., sigma
Baker Perkins 300 gallon Stainless Steel Size 18DIM Sigma Blade MIXER, 30 HP motor
42" Tolhurst CENTRIFUGE Perforate
Nash L3 Stainless VACUUM PUMPS 140 CFM (3)
11,500 gal. Stainless TANKS Agitated
48"x41' Vulcan Stainless BUBBLECAP COLUMN 40 trays, 70 caps/tray, 100 PSI design
72"x30' Budd Stainless BUBBLECAP COLUMN 21 trays, 38 caps/tray
Pfaudler 500 gal. ELL GLASS LINED REACTOR, agitated, 75 PSI jacket, 25 PSI internal
Pfaudler 300 gal. EL GLASS LINED REACTOR, agitated, 90 PSI jacket, 25 PSI internal
8000 gal. Stainless 316 TANKS 10'x14' vertical
4500 gal. 347 Stainless COIL PANS, 6'x20' (2)
5'3"x3' Oliver Precoat Rotary VACUUM FILTER, Vaporite, 316 Stainless
Link Belt 604-24 Stainless ROTO-LOUVRE DRYER
1860 sq. ft. Stainless REBOILER 271-1"x12' tubes
8'x60'x⅝" Allis-Chalmers ROTARY KILN
60"x84" Single deck Rotex #421 SCREEN
Swanson EVAPORATOR 435 sq. ft. Stainless, single effect condenser, vapor separator
1000 gal. Dopp Ni-resist jktd., agit. REACTOR
1000 gal. Steel REACTOR, jacketed & agitated
LaBour PUMP 316 STAINLESS 125 GPM @ 211'
500 ft. Glass lined jacketed PIPE 2", 3" and 4"
306 sq. ft. STAINLESS EXCHANGER, ¾" tubes
36"x20' COLUMN 316 Stainless Packed, 100 PSI
4'x40'x⅜" ROTARY DRYER NEW welded shell
2000# Stainless RIBBON BLENDER 32"x96"
LaBour PUMP STAINLESS STEEL 750 GPM @ 80'
4000 gal. Vert. Type 347 TANK
6'x36" Hardinge CONICAL BALL MILL, 75 HP
Buflovak 6' jacketed vacuum CRYSTALLIZER
1000 sq. ft. STAINLESS EXCHANGER, ¾" tubes
10'x150' ROTARY KILN complete
78"x18' STAINLESS 316 BUBBLECAP COLUMN 14 trays, 180 caps/tray, 100 PSI
12"x18' STAINLESS PACKED COLUMN, 100 PSI
8'x150' ROTARY KILNS complete (2)
8'x90' ROTARY DRYER complete
3,500 gal. 304 Stainless TANKS 8'x9' Vertical
2,300 sq. ft. Stainless EXCHANGER, 1" tubes
16"x10'7" Pfaudler GLASS LINED SCRUBBER COLUMN 25 PSI and full vacuum
Swenson Stainless Jkt. CRYSTALLIZERS 24"x20'

Write for catalogs

HEAT & POWER CO. INC.
60 E. 42nd Street, New York 17, N. Y. MU 7-5280
310 Thompson Bldg., Tulsa 3, Okla. LU 3-4890

CIRCLE T ON READER SERVICE CARD

BOILERS—500 HP—150 PSI—package gas/oil—New late 1957

CRYSTALIZER—482 cu. ft.—316 s/s Struthers Wells "Krystalizer"

FILTERS—string discharge
8' x 8' FEINC—Rubber covered
4'6" x 8' FEINC—Rubber covered.

VACUUM RCVRS.—7'6" dia. x 9' deep—rubber line—w/Schutting & Koerting Jet vacuum pumps.

MIXING TANK—5800 gal. Neoprene lined w/motorized Agitator.

LAWLER COMPANY
Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE U ON READER SERVICE CARD

SPECIALS

Steam Generator: Clayton 100 hp. 100 #WP.
3-roll Mill: Day 10 x 22" high speed 2-speed.
3-roll Mill: Lehmann 12x32" high speed 25 hp.
Pebble Mills: Abbe #3, #6, and others.
Dryer: American, 24 x 48" dbl. drum.
Dryer: Bowen lab. spray, st. st.
Evaporator: Buflovak, sgl. eff, st. st. 94 sq. ft.
Dryer: Porter 2 x 4' vac. drum, st. st.
Centrifugal: Tolhurst 26" rubber 2-speed.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12 x 2" type 316 st. st.
Kettles: Stainless Steel—Send for our list.
Dryer: Proctor & Schwartz 6-tray st. st.
Powder Mixers: Day Jumbo 120 cu. ft.

Write us or call Seeley 8-1431
Send us a list of your idle machines

LOEB EQUIPMENT SUPPLY CO.
818 W. Superior St., Chicago 22, Ill.

CIRCLE V ON READER SERVICE CARD

COMPRESSORS

No better values at any price

65 CFM 600 PSI 5¾-2¼x5 Gardner ABD
138 CFM 100 PSI 7x7, Ing. ES. CP & Joy
288 CFM 100 PSI 9x9 Ing. Worth, CP
306 CFM 100 PSI 9x7 Joy WG9
321 CFM 125 PSI 10x11 IR, CP, Worth
445 CFM 125 PSI 7½-5¾x5 Gard WBH 4010
460 CFM 125 PSI 10-6x7 Joy WN 102
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
676 CFM 110 PSI 15-9¼x12 Ing. XRB 3-60-440
686 CFM 100 PSI 14x13 Ing. ES Gardner
1065 CFM 110 PSI 18-12x14 Ing. Rand XRE 175 HP Syn 3-60-440
1650 CFM (actual) 125 PSI C300-300H Fuller 350 HP Syn. 3-60-440 .8 PF
2200 CFM 100 PSI 26-15x28 Ch. Pn. oce 350-HP 3-6-4600 .8 PF
2230 CFM 110 PSI 25-15x12 Ing. Rand XVH 350 HP GE Syn. 3-60-440

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE W ON READER SERVICE CARD

$34 MILLION PLANT LIQUIDATION

OKLAHOMA ORDNANCE WORKS
PRYOR, OKLAHOMA

COMPLETE UNITS
EQUIPMENT—BUILDINGS
for use in place or removal

10,000 Acres With All Utilities For Industrial Plants

Lowest Gas—Electricity & Water Rates

Excellent Effluent Disposal Areas

Plants For Use In Place

- NITRIC ACID
- DIMETHYLANALINE
- AMMONIA OXIDATION
- TETRYL
- NITRO CELLULOSE
- ALCOHOL
- ETHER
- DIPHENYLAMINE
- SELLITE
- SULPHURIC ACID CONCENTRATING

This plant was put in excellent stand-by condition by the Government. All equipment is ready to go back into service, now!

Leasing or Financing Available For Complete Units In Place or Individual Equipment

Catalog being prepared. Write for your copy.

HEAT & POWER CO. INC.
60 E. 42nd Street, New York 17, N. Y. MU 7-5280
310 Thompson Bldg., Tulsa 3, Okla. LU 3-4890

CIRCLE Y ON READER SERVICE CARD

Hold down your overhead with GELB CHEMICAL PROCESS EQUIPMENT

1—Cowles type 316 SS dissolver, Model 20D with 20 HP explosion proof motor
1—Sparkler SS horizontal filter, Model 33-D-7
2—SS 11,000 gals. vertical storage tanks
1—Buflovak 6" x 8" chrome plated double drum dryer, complete

AUTOCLAVES, KETTLES, REACTORS, TANKS

3—Glascote Model HR 1500 gal. glass lined jacketed reactors, complete with impeller type agitators, baffles and drives
1—Pfaudler Series R 1500 gal. glass lined jacketed reactor, complete with impeller type agitator, baffle and drive
1—Pfaudler 750 gal. glass lined jacketed reactor
1—Glascote 750 gal. glass lined jacketed vacuum receiver
1—Pfaudler type 316 SS 750 gal. reactor
72—Alloy Fabricators 400 gal. SS jacketed reactors complete with agitators and drives
2—Pfaudler Series EM glass lined jacketed reactors complete with agitators and drives, 400 and 300 gals.
3—Pfaudler type 316 SS jacketed reactors, 200 and 100 gals.
1—Struthers Wells 300 gal. Hastelloy "B" jacketed kettle
1—Blaw Knox 300 gal. SS vacuum reactor
1—Van Alst 300 gal. SS jacketed kettle
1—125 gal. SS jacketed autoclave with impeller type agitator and drive, 125 psi jacket, 75 psi internal
3—Vertical SS storage tanks, 12,500 gals.
1—2000 gal. SS storage tank
10—Pfaudler Series P glass lined jacketed reactors, 20, 30, 50 and 100 gals.

CENTRIFUGES

2—Sharples type 316 SS nozljectors with 40 HP explosion proof motors
2—AT&M rubber covered suspended type centrifuge with 36" perforate basket, motor and plow
1—Merco SS centrifuge, Model C-9
1—Baker Perkins SS Termeer centrifuge, Model HS-24, complete
1—AT&M 26" type 316 SS suspended type centrifuge
2—AT&M 12" SS suspended type centrifuges
1—Bird SS 40" suspended type centrifuge complete with perforate basket, plow and motor
1—Sharples type 316 SS centrifuges, Model D-2
5—Tolhurst 40" x 30" rubber covered centrifuges
3—Western States type 316 SS 40" suspended type centrifuges, complete with perforate baskets, plows and motors

DRYERS

1—Bartlett & Snow rotary dryer, 3' x 16', complete—NEW
17—Stokes type 304 SS jacketed rotary vacuum dryers, 3' x 10' and 3' x 15'
1—Stokes SS jacketed rotary vacuum dryer, 2' x 6'
2—ADT SS lined rotary steam tube dryers, 42" x 30' long
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
1—Allis Chalmers SS rotary dryer, 6' x 50'
1—American 42" x 120" double drum dryer, ASME, complete
1—Buflovak SS jacketed rotary vacuum dryer, 5' x 30'
1—Buflovak steel jacketed rotary dryer, 3' x 15'
2—Louisville 8' x 50' SS rotary dryers
1—Link Belt steel roto louver dryer, Model 207-10
1—Link Belt steel roto louver dryer, Model 502-20
2—SS pilot plant spray dryers

THE GELB GIRL—DECEMBER 1961

FILTERS

1—Niagara SS filter, Model 510-28
1—Niagara SS jacketed filter, Model 33-12-D
2—Sperry 36" x 36" rubber covered filter presses, 27 chambers
10—Shriver plate and frame filter presses, 12" to 42"
12—Sweetland #12 pressure leaf filters with 72 stainless leaves

MIXERS

15—SS double cone jacketed vacuum blenders, 10 cu. ft.
2—SS horizontal double ribbon jacketed blenders, 62 cu. ft.
1—Young SS double ribbon blender, 4 cu. ft., complete
1—Baker Perkins 150 gal. dispersion type mixer, complete
1—J. H. Day 200 gal. SS double arm sigma blade jacketed mixer
1—J. H. Day 5 gal. double arm sigma blade jacketed mixer, SS
15—Robinson type 304 SS horizontal blenders, 255 cu. .ft
1—Robinson type 304 SS horizontal blender, 125 cu. ft.
3—Sprout Waldron 30 cu. ft. jacketed ribbon blenders, steel
1—Stokes SS granulating mixer, Model 21-J
1—Sturtevant #7 dustite rotary batch blender—NEW

MISCELLANEOUS

18—Davis Engineering heat exchangers, SS, 115, 134, 156 and 208 sq. ft.—NEW
150—Worthington and Durimet centrifugal pumps, 4 x 3, 3 x 2, 2 x 1½, etc.
3—Badger SS heat exchangers, 500 and 600 sq. ft.
4—Patterson SS condensers, 200 and 300 sq. ft.
4—Pfaudler glass lined thimble type condensers, 9, 14, and 62 sq. ft.
1—Patterson-Kelley Carpenter 20 heat exchanger, 520 sq. ft.
1—Struthers Wells SS 1150 sq. ft. single effect evaporator
2—Cleaver Brooks package steam generators, 150 HP and 500 HP, 160 psi
1—Superior 300 HP package steam generator, 125 psi
1—Raymond 2 roll high side mill
1—Williams "Comet" 4 roll mill, complete
1—Sprout Waldron pelletizer, Type 501 FF
2—Mikro #3TH SS pulverizers
3—Mikro Bantam pulverizers
1—Vulcan SS bubble cap column, 4' dia. x 25 plates
1—Stokes rotary tablet press, Model RDS-3

1—Alloy Fabricators 5000 gal. jacketed reactor, complete with agitator and drive
1—Eimco SS rotary vacuum filter, 4' x 4'
15—Stokes type 304 SS jacketed rotary vacuum dryers, 3' x 10', 3' x 15'
3—Glascote Model HR 2000 gal. glass lined jacketed reactors, complete with impeller type agitators, baffles and drives

R. GELB & SONS, INC. — ESTABLISHED 1886 — PROCESS MACHINERY · UNION, N. J. — 75 ANNIVERSARY

U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900

CIRCLE Z ON READER SERVICE CARD

Index to Advertisers

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

Advertising Sales Representatives

Atlanta 9 .... R. K. Burnet
1375 Peachtree St., N. E., TRinity 5-0523
Boston 16 .... A. S. Reed
McGraw-Hill Bldg., Copley Square, COngress 2-1160
Chicago 11 .... Gene Davis, Harvey Dunn
645 N. Michigan Ave. MOhawk 4-5800
Cleveland 13 .... John C. Mitchell
55 Public Square SUperior 1-7000
Dallas 1 .... F. E. LeBeau
Vaughn Bldg., 1712 Commerce RIverside 7-9721
Denver 2 .... John Patten
1700 Broadway ALpine 5-2981
Detroit 26 .... Chas. M. Crowe, Jr.
856 Penobscot Bldg. WOodward 2-1793
Frankfurt/Main .... Stan Kimes
85 Westendstrasse
Geneva .... Michael R. Zeynel
2 Place du Port
Houston 25 .... J. C. Page
W-724 Prudential Bldg. JAckson 6-1281
London W. 1 .. E. S. Schirmer, Edwin E. Murphy
34 Dover St.
Los Angeles 17 .... John B. Uphoff
1125 W. Sixth St. HUntley 2-5450
New York 36 .. R. G. Frederick, A. L. Gregory, Johnson C. Blake
500 Fifth Ave. OXford 5-5959
Philadelphia 3 .... M. A. Loy, Jr., L. D. Zerone
6 Penn Center Plaza LOcust 8-4330
Pittsburgh 22 .... G. S. Ryan
4 Gateway Center EXpress 1-1314
Portland 4 .... Scott B. Hubbard
Room 445, Pacific Bldg. CApitol 3-5118
St. Louis 3 .... Harvey Dunn
7751 Carondelet Ave. PArkview 5-7285
San Francisco 11 .... John Hernan
255 California St. DOuglas 2-4600

The VITAL Link

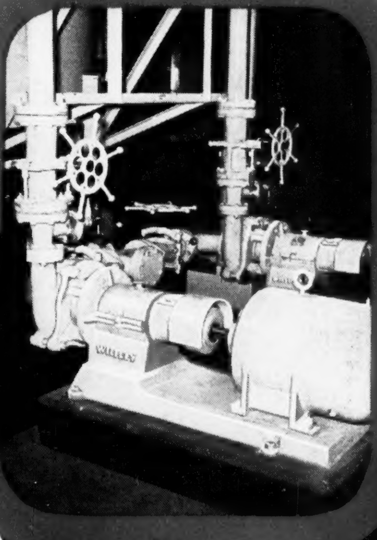
IN YOUR PRODUCTION CHAIN

Downtime slows production or stops it entirely. Eliminate expensive shutdowns by installing Wilfley Acid Pumps.

Dependable, maintenance—free performance has become synonymous with the name Wilfley. Year after year, in countries throughout the world, Wilfley Acid Pumps operate continuously without attention, providing lower pumping costs in every installation.

When you are pumping corrosives, hot liquids, or mild abrasives, there's a dependable Wilfley Acid Pump to do the job for you. Pumping parts are available in a variety of metal alloys as well as plastic. 1″ to 8″ discharge sizes with 10 to 3000 GPM capacities, heads to 200′ and higher.

EVERY INSTALLATION IS JOB ENGINEERED



WILFLEY

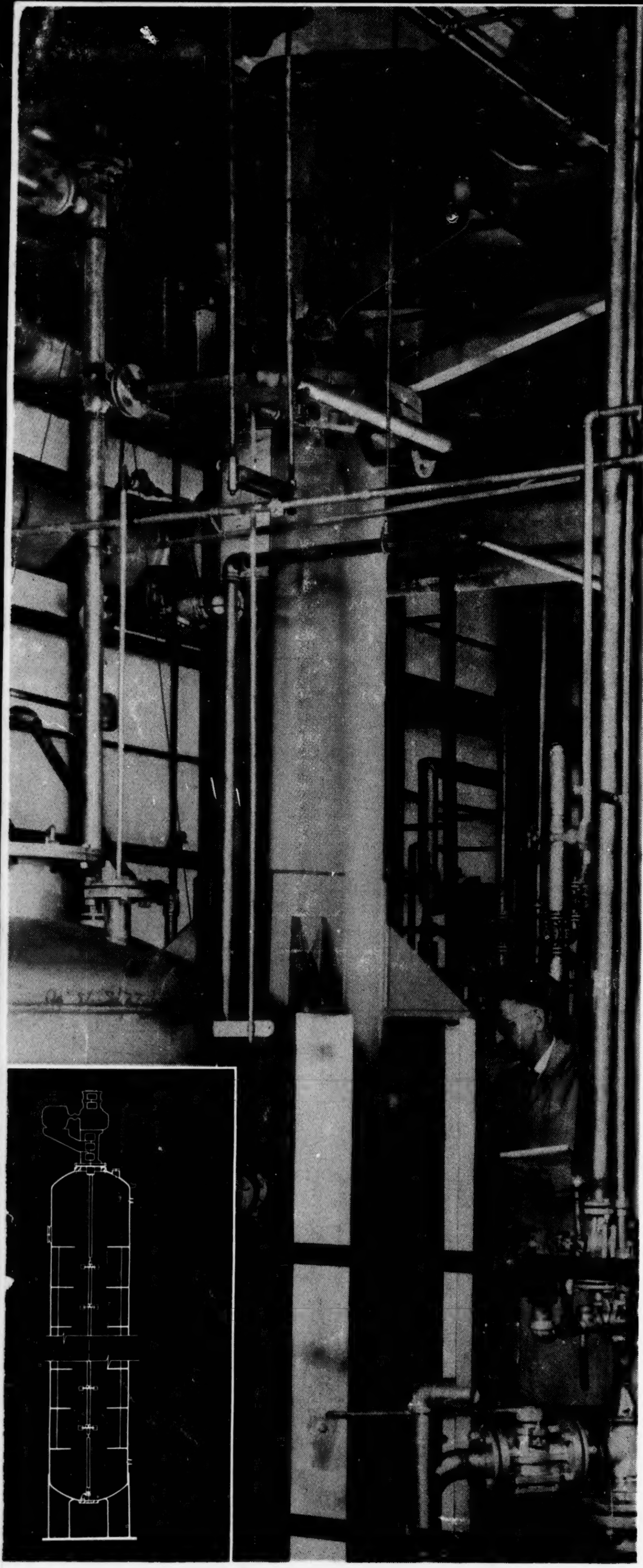
ACID PUMPS

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

Write, Wire or Phone for complete details.

A. R. WILFLEY and SONS, Inc.

Denver, Colorado, U.S.A. • P.O. Box 2330
New York Office: 122 East 42nd St., New York City 17, N.Y.



CMCONTACTOR can be pilot plant size or as large and as high as needed. Corrosion-resistant materials are readily supplied. Here a CMContactor reclaims a chemical from process liquor at photo chemicals division of Eastman Kodak Company.

LIGHTNIN CMContactor

new multi-stage mixing column handles anything that flows

Don't freeze your plans for "going continuous" on a process until you've had a chance to see what the new LIGHTNIN CMContactor can do for you.

In one package it combines mixer and process vessel, designed to fit your needs, in materials of your choice. It can accommodate *any* fluids, including gas dispersions, heavy slurries, and thick viscous liquids.

It handles any type of continuous operation. And it gives you predictable results.

Here's why you'll find you can get results with the CMContactor that you can't get any other way:

1. **No fouling or plugging.** Simple, self-cleaning design makes it possible to handle fluids of high solids content. Solids can be carried through with the flow stream, settled against the liquid flow current, or retained in the column.
2. **No guessing when you scale up.** Fully baffled system means a controlled flow pattern within each stage, free from problems of channeling, wall effects, packing wettability, and head differentials. Pilot plant conditions can be duplicated with precision in columns of any size.
3. **Selected mixer speed for each flow rate.** As flow rate changes, mixer speed can be adjusted to give optimum performance for that specific throughput.

We help you pilot-plant the process. We'll test-run it for you in our own laboratory. Or you can rent or buy a pilot CMContactor and we'll help you with your own test runs.

To get a fuller idea of the efficiency this versatile new process tool can bring to your operations, call in your LIGHTNIN Mixer representative now. He's listed in Chemical Engineering Catalog and in the yellow pages of your telephone book. Or write us direct.

3.2 84.

Lightnin Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 128-n Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England.

ACTOR

olum
flows

uous" o
what th
you.
l proces
terials o
luids, in
and thic

ion. An

ults wit
ther wa

cleanin
fluids o
carrie
ainst th
column

y baffle
n withi
nneling
head di
be dupli
y size.

. As flo
usted t
specifi

est-run i
n rent o
you wit

versati
erations
ve now
alog an
ook. O

ester 3, N.Y.
a Ave.,
gland.